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BEFORE THE

Federal Communications Commission

WASHINGTON, D.C. 20554

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FEDERAL COMMUNICATIONS COMMISSION
OFFICE OF THE SECRETARY

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

COMMENTS OF THE U.S. GPS INDUSTRY COUNCIL ON TEST DATA REGARDING POTENTIAL INTERFERENCE FROM ULTRA-WIDEBAND TRANSMISSION SYSTEMS

The U.S. GPS Industry Council ("the Council"), by its attorneys and pursuant to a Commission Public Notice,[1] hereby submits these Comments on the National Telecommunications and Information Administration's ("NTIA") Special Publication entitled, "*Assessment of Compatibility between Ultrawideband ("UWB") Systems and Global Positioning System ("GPS") Receivers.*"[2] The NTIA Report, while representing a non-comprehensive assessment of the potential for interference from UWB transmission systems into GPS receivers that is based on considerations and scenarios favorable to the proponents of UWB, demonstrates beyond any question that UWB transmission systems will cause harmful interference to GPS receivers in virtually every application in which GPS technology is used today. Although further

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[1] Report No. DA 01-753, *Comments Requested on Re[prts Addressing Interference from Ultra-Wideband Transmission Systems (ET Docket No. 98-153)* (released March 23, 2001) ("*Public Notice*").

[2] NTIA Special Publication 01-45, *Assessment of Compatibility between Ultrawideband ("UWB") Systems and Global Positioning System ("GPS") Receivers*, David S. Anderson, et al. (February 2001) ("NTIA Report"). The Commission also sought public comment on reports pertaining to UWB interference to GPS receivers that were prepared separately on behalf of the Department of Transportation (dated March 21, 2001) and UWB proponent Time Domain, Inc. (dated March 9, 2001). *See Public Notice*. In these Comments, the Council focuses its GPS-related analysis and comments on the NTIA Report. The Department of Transportation results are much less comprehensive than, although not generally incompatible with, the results reached by NTIA. The results reached in the report funded by Time Domain, however, are suspect on multiple technical levels. Shortcomings in the analytical approach began to emerge nearly one year ago, and have been commented upon in multiple fora since. In each instance, the researchers refused all suggestions to improve the processes that were employed. Under these circumstances, there simply is no basis on which the Commission can find the Time-Domain-funded exercise reliable for purposes of the instant proceeding. The NTIA Report, by contrast, while not immune to criticism, is nevertheless worthy of consideration by the Commission as the instant rulemaking proceeding progresses.

testing is needed to refine the results, it is absolutely clear that the unlicensed operation of UWB devices – under Part 15 of the Commission's rules or not – must be strictly prohibited in frequency bands used or planned for use by GPS and its augmentations.[3]

I. INTRODUCTION

The Council is a non-profit 501(c)(6) industry trade association whose mission is to act as a GPS information resource to the Government, the media, and the public.[4] Its purpose is to promote sound policies for the development of commercial markets in civilian applications, while preserving the military advantages of GPS. The Council provided extensive comments and reply comments last Fall in response to the Commission's Notice of Proposed Rule Making in the above-captioned proceeding,[5] and has been an active participant in every phase of this proceeding (and associated UWB proceedings) at the Commission.[6]

II. DISCUSSION

A. The NTIA Report Confirms The Detrimental Interference Impact Of UWB Transmissions on GPS Receivers.

In its Report, NTIA sagely observes that "[b]efore [it] can agree to emissions from UWB devices in restricted frequency bands used by critical Federal Government radiocommunicaion systems, it must ensure that there is no potential interference introduced from their proposed operations. The Global Positioning System (GPS) is an example of a critical radionavigation

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[3] These bands include substantial portions of the bands 1164-1215 MHz; 1215-1300 MHz; and 1559-1610 MHz.

[4] Current membership includes the principal U.S. manufacturers of GPS equipment — *e.g.*, Boeing, Honeywell, Magellan/Orbital Sciences, Rockwell International, and Trimble.

[5] *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*").

[6] *See* Comments of the U.S. GPS Industry Council, ET Docket No. 98-153 (filed September 12, 2000) ("Council Comments"); Reply Comments of the U.S. GPS Industry Council, ET Docket No. 98-153 (filed October 30, 2000) ("Council Reply Comments").

system that operates in several of the restricted frequency bands."[7] This assessment, of course, corresponds to the Commission's own proposal, in the *UWB NPRM*, that safety services and other users of bands that are off-limits to Part 15 devices (including the radionavigation-satellite service ("RNSS") bands used by GPS) be fully protected from harmful interference that may be caused by UWB transmissions.[8] With this admonition in mind, NTIA set out to define the maximum allowable UWB equivalent isotropically radiated power ("EIRP") levels that can be tolerated by GPS receivers without causing degradation to their operations, and to compare the EIRP levels identified with the existing limitations on unlicensed devices in Part 15 of the Commission's Rules in order to assess the applicability of the limits to UWB devices.[9]

As NTIA explains in its Report, it undertook a public process of identifying a series of operational scenarios in order to relate the interference level at the input of the GPS receivers used in various applications (terrestrial, maritime, railway, surveying, and aviation) to the emissions produced by UWB devices. The Council was an active participant in the process of articulating the scenarios, and agrees that the cases chosen are representative of what may be experienced if the deployment objectives and aspirations identified by UWB proponents and supporters during the initial comment phase of the *UWB NPRM* were to be fulfilled.[10]

Nevertheless, the Council maintains that some of the assumptions that are embedded in the operational scenarios produced in the NTIA Report are inaccurate, and suggest in certain instances

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7 NTIA Report at iii. *See also id.* at 1-3.

8 *Id. See also Revisions of Part 15 of the Commission's Rules Regarding Ultra-Wideband Transmission Systems,* Notice of Proposed Rule Making, ET Docket No. 98-153, FCC 00-163, slip op. at ¶¶ 23, 28, and 29 (released May 11, 2000) ("*UWB NPRM*").

9 NTIA Report at 1-4.

10 Although representative of the types of applications that GPS receivers are found in, the scenarios developed by NTIA by no means cover the field. As shown in Attachment 1 to these Comments, there are whole classes of GPS applications that are not taken into account in the assessment program conducted to date by NTIA. The list of GPS applications considered in Attachment 1 is taken from the Report of the International Telecommunication Union ("ITU") Conference Preparatory Meeting for the 2000 World Radiocommunication Conference, which addressed spectrum issues regarding the RNSS service within which the GPS operates.

that the interfering UWB emissions will be farther away from the victim GPS receivers than would actually be the case, and/or would in aggregation situations be present in lower numbers than they would in a real-world situation. For example, in the case of terrestrial GPS receivers used in applications such as Enhanced-911-equipped cellular phones or emergency response vehicles, a minimum distance separation of two meters from an interfering UWB device is assumed.[11] Based on the types of widespread outdoor uses of UWB devices that are reflected in the comments filed on the *UWB NPRM*, where UWB is projected for use in such applications as anti-collision radars on cars, electronic messaging systems, and even mobile telecommunications, a separation distance of two meters appears to be too large. A true co-location scenario would have been more appropriate. Similarly, in the stated scenario for multiple "outdoor" UWB emitters impacting a terrestrial GPS receiver, the assumption is for four UWB interferors that are each separated from the victim GPS receiver by ten meters.[12] Again, based on the deployment objectives identified in comments filed with the Commission by UWB proponents and supporters, this appears to the Council to be a dramatic understatement of the number of interferors and an overstatement of the minimum separation distance that is likely to be experienced in a real-world situation.

The upshot here is that the operational scenarios reported by NTIA appear to be more favorable to the UWB interests than they would be if real-world expectations had been accurately incorporated into the scenarios. In light of the fact that many of the GPS applications reflected in the scenarios are safety-of-life applications, this is a surprising tilt, and one that should legitimately have gone in the other direction. The Council highlights this development not to grouse about the efforts that NTIA went to in its testing program; instead, it calls this development to the Commission's attention in order to emphasize that the conclusions NTIA reached when

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[11] *See* NTIA Report at 3-9.

[12] *Id.* at 3-10.

utilizing these scenarios – conclusions that, as will be explored below, demonstrate beyond question the devastating interference impact that UWB emissions will have on the panoply of GPS applications – should in fact be even worse in practice than have been reported by NTIA.

With regard to the results NTIA reports, NTIA states that "[t]he data collected in this assessment demonstrates that when considered in potential interactions with GPS receivers used in applications represented by the operational scenarios considered in this study, some of the UWB signal permutations examined exceeded the measured GPS performance thresholds at EIRP levels well below the current Part 15 emission level."[13] While true, this appears to be a substantial understatement of the impact.

The analysis produced by NTIA covered 74 GPS applications, some of which involved multiple UWB interference scenarios (e.g., a single UWB emitter, multiple UWB emitters, indoor UWB use, and/or outdoor UWB use) and differing UWB pulse repetition factors (which ranged from 100 kHz to 20 MHz).[14] Of the 74 cases tested, only 9 (or roughly 12%) show that the level of interference produced by the UWB devices would be at levels that meet the –71.3 dBW/MHz limit in Part 15 of the Commission's rules; fully 65 of the 74 cases (or 88%) show that interference to the GPS receivers analyzed occurs at EIRP levels that below the Part 15 limit.

Figure 1 below contains a chart (with cases corresponding to Table 1 from the Executive Summary of the NTIA Report) plotting both the current Part 15 limit and the results of the tests.[15] Clearly, GPS receivers of every class tested are impacted – some by interference as much as 35 dB below the Part 15 limits – by UWB emissions.

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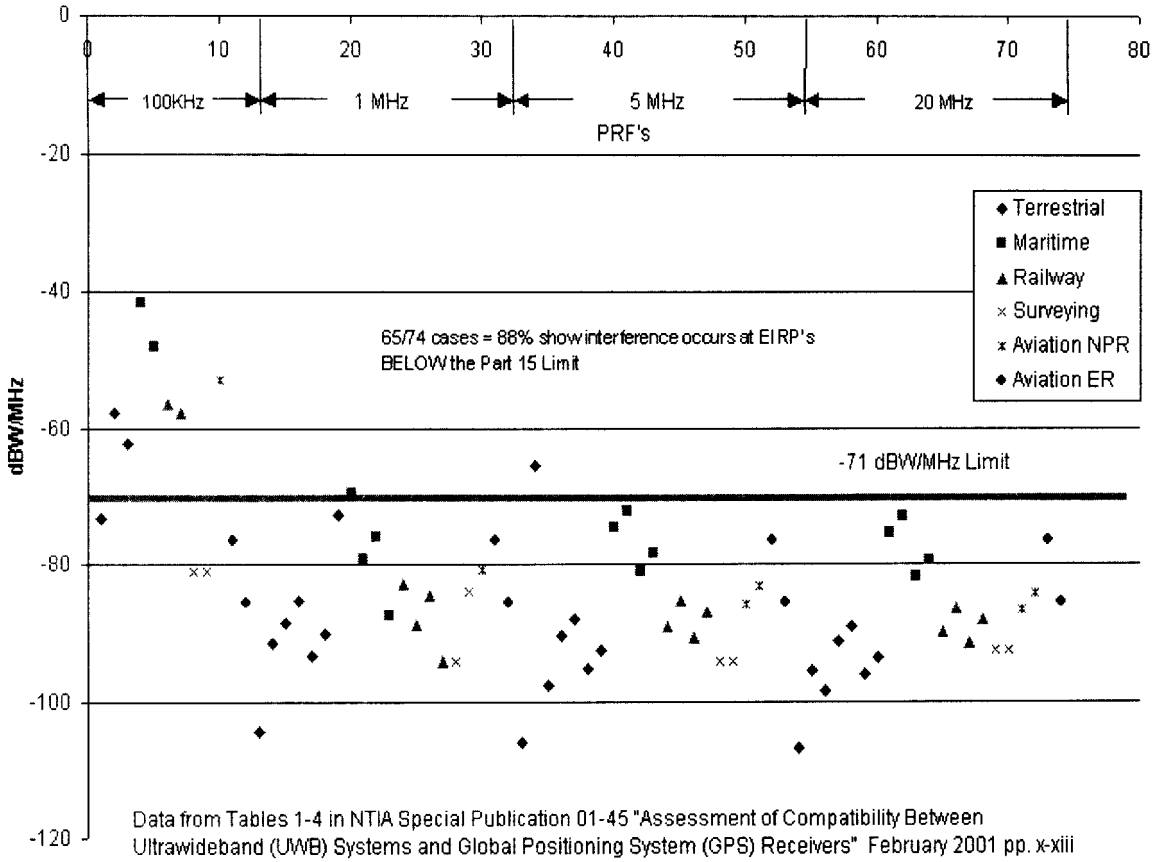
[13] NTIA Report at xx.

[14] *Id.* at x-xiii.

[15] Attachment 2 to these Comments contains a reproduction of Figure 1, with the case numbers from Tables 1 to 4 from the NTIA Report, pp. x-xiii, that are assigned to the values in Figure 1. A reproduction of Tables 1 to 4 with the case numbers shown is included in Attachment 2.

FIGURE 1: UWB EIRP Interference to GPS By Class of Signal



On the basis of the NTIA Report, and the summaries of NTIA's own data, it is clear that UWB emissions, at practically any of the levels examined and with regard to every class of GPS application assessed, will produce harmful interference to GPS if permitted to operate on a co-frequency basis with GPS.[16] In light of these results, there simply is no way for the Commission to determine that UWB devices of any kind are able to be authorized for operation on an unlicensed basis.

[16] By co-frequency, the Council is referring to a UWB device that has an operational range that includes the RNSS bands between 1164 and 1610 MHz. As noted, NTIA considers a device to be a UWB device if it has an instantaneous bandwidth of 25 percent or more of its center frequency. This means that for a UWB device with a center frequency of 2.0 GHz, for example, the bandwidth would be at least 500 MHz. The Council notes that it has, in previous comments, questioned the efficacy of this definition.

B. As Was the Case With the Non-GPS Test Results, NTIA's GPS Test Results Cannot Form The Basis For Any General Rules That Permit UWB Operations On Any Basis In Bands Below 3.1 GHz Or On An Unlicensed Basis In Any Band.

In considering the results of NTIA's earlier tests on the interference effects of UWB emissions on the limited class of tested non-GPS equipment, the Council opined that "the test results reported by NTIA cannot form the basis for any rules of general applicability that would permit UWB operation. Indeed, they reveal the existence of an interference problem of sufficient magnitude to preclude all UWB transmissions below 3.1 GHz, and to permit unlicensed operation of UWB devices only above 3.1 GHz, provided that such UWB devices are not permitted to operate in any restricted or safety-of-life band."[17]

In addition, the Council noted in its earlier comments that the critical technical, operational, and business challenge is to determine whether the noise floor can be managed on a shared basis among services with different business goals and customer objectives. All of the testing to date – including the tests reported in the latest NTIA Report – has centered on only a few examples of monopulse transmissions, and there have been no serious studies of what happens to the noise floor in an environment where multiple, large-scale, saturated networked communications services from different competitors are operating on a continuous basis with high data-rate transmissions and peak power. Still, it is reasonable and logical to project that the results anticipated from such studies, once undertaken, are that the negative impact of such UWB interference on GPS will be profound, given that the monopulse waveforms tested to date indicate

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[17] Comments of the Council on NTIA Non-GPS Test Results, ET Docket No. 98-153, at 3 (filed February 23, 2001). In support of this statement, the Council noted shortcomings regarding the clarity of the definition of UWB emissions employed in the testing program (inviting exploitation of the term and abuse by proponents of certain emerging classes of network-capable communications devices); the lack of quantification of the interference threat presented by UWB; and the fact that NTIA had not tested for the total amount of interference that would be produced by one or more UWB communications networks operating on a continuous basis at peak power and capacity with a high data rate. *Id.* at 3-4.

that GPS and other extant systems will receive harmful interference even at EIRP levels 20 to 30 dB below the limits currently included in Part 15 of the Commission's rules.[18]

The considerations the Council identified in its comments on the non-GPS NTIA testing report apply here as well. They are heightened dramatically, however, by the fact that NTIA's GPS testing has clearly revealed that ***there is no single class of UWB emitter tested that uniformly performed at levels that meet the Part 15 emission limits, nor is there any single category of GPS receiver, that has been shown to be immune from UWB emissions.***

With these results, and with the vast majority of GPS applications and UWB waveforms not yet tested, there is absolutely no basis upon which the Commission can – consistent with its initial objectives in this proceeding regarding protection of GPS from harmful interference, or indeed, consistent with its statutory mandate to take actions that advance the public interest, convenience, and necessity – adopt any rule that permits UWB devices to be operated (i) on an unlicensed basis in any frequency band; or (ii) to be operated on any basis within the bands 1164-1610 MHz that are allocated to RNSS and used by GPS. NTIA itself admonishes against generalization of its test results by stating that "these results are applicable only to those UWB signal permutations examined within this study and to those applications of GPS that are defined by the operational scenarios presented for consideration herein."[19]

The Council, from the outset, has not contested the claims and visions put forth by UWB proponents and their supporters regarding the potential applications of UWB and the potential ubiquity of the technology's deployment. Instead, it has admonished that the stakes of permitting UWB devices to be operated in bands used by GPS and other sensitive existing services (some of which are communications services and some of which are not) are too high to allow

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[18] *Id.* at 4-5.

[19] NTIA Report, at xxi.

most UWB operations to be permitted on a co-frequency basis. In order to enable the Commission and the marketplace to determine whether there is any merit to UWB technology, the Council renews its suggestion that the Commission conduct a carefully crafted strategic experiment whereby a segment of spectrum 3GHz wide, located well above 3.1 GHz and excluding restricted bands, would be established for very low power ultrawideband devices. Such an approach, which would, of course, require cooperation and spectrum management by UWB operators, would enable the world to ascertain whether UWB technology is an economically workable long-term allocation concept. Only upon a successful conclusion of such a strategic experiment will the Commission be in any kind of position to consider extending this experiment to higher powers and more frequencies – again away from bands restricted for safety purposes.[20]

C. The Commission Should Initiate A Further Notice Of Proposed Rule Making To Provide An Opportunity For Public Comment On Any Rules It Proposes Once Comments On The Various Testing Programs Have Been Taken.

This rulemaking proceeding is addressing a complex and largely unknown subject, and the first test results in from NTIA reflect the need for the development of complex rules to accommodate UWB devices. No specific rule proposals were made in the *NPRM*.

Under these circumstances, and given the significance of the issues under consideration and the stakes involved for incumbent services, the Council restates its strong belief that the Commission must issue a Further Notice of Proposed Rule Making (FNPRM) before adopting any specific rules – other, perhaps, than a rule that excludes the unlicensed operation of UWB devices and restricts further inquiries into UWB to bands above 3.1 GHz. Such an approach is necessary to ensure that all interested parties have a reasonable opportunity to comment upon any rules the Commission may wish to establish based on the record developed to date, and that all services,

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[20] Council Non-GPS Comments at 7-8.

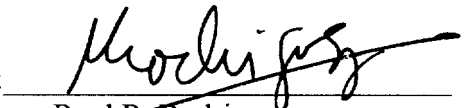
operational and planned, are provided the regulatory certainty they need to meaningfully assess the applicable technical and business risks, and is mandated by the Administrative Procedure Act.

III. CONCLUSION

Despite the fact that NTIA has not conducted a comprehensive examination of the impact of UWB devices on GPS receivers, and despite the fact that scenarios under which the interference effects of UWB on GPS receivers were assessed are unduly favorable to those on the UWB side of the equation, it is alarming to discover that the impact of UWB interference on GPS receivers is profound. There is no GPS application that appears to be immune for UWB interference, and there is no class of UWB emitter that appears to be universally benign in its interference impact. Under these circumstances, it is clear to the Council that no UWB devices should be permitted to operate below 3.1 GHz and no UWB devices (licensed or unlicensed) should be allowed to operate in bands restricted for safety-of-life.

Respectfully submitted,

THE U.S. GPS INDUSTRY COUNCIL

By: 

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Its Attorneys

ATTACHMENT 1

Item No.	CPM Uses of RNSS	Operational Scenarios Described in NITA 01-45 Pages 3-7	GPS Application (by Receiver) Described in NITA 01-45 Pages x-xiii
1	**Agriculture and Forestry:**		
	Ploughing, planting & fertilizing without operators	Precision Machine Control	NTIA/Surveying
	Forest area & timber estimate	Geographic Information Systems (GIS)	NTIA/Terrestrial
	Identifying species habitats	GIS	NTIA/Terrestrial
	Fire perimeters	GIS	NTIA/Terrestrial
	Water resources	GIS	NTIA/Terrestrial
	Locating property boundaries		
2	**Aviation:**		
	Oceanic and enroute navigation	En-route Navigation &	NTIA/Aviation Enroute
	Non-precision and precision all-weather approaches	Non-Precision Approach	NTIA/Non-Precision Approach
	Precision Approach	Not addressed in NTIA	RTCA/p. 45 Table 4.2
	Improved aircraft separation standards	Not addressed in NTIA	Not addressed
	Airport surface traffic management	Not addressed in NTIA	Not addressed
	Wind shear detection	Not addressed in NTIA	Not addressed
	Precise airfield and landing aid location	Not addressed in NTIA	Not addressed
	Monitor aircraft locations in flight	Not addressed in NTIA	Not addressed
	Precision Departures	Not addressed in NTIA	Not addressed
	Missed approach applications	Not addressed in NTIA	Not addressed
	Enhanced gound proximity warning system	Not addressed in NTIA	Not addressed
	Automatic depended surveillance	Not addressed in NTIA	Not addressed
3	**Electric Power:**		
	Synchronizaiton of power levels	Not addressed in NTIA	Not addressed
	Event location	Not addressed in NTIA	Not addressed
4	**Emergency Response:**		
	Public Safety (EMS vehicles)		NTIA/Terrestrial
	Public Safety (Mobile E911)		Not addressed
5	**Environmental Protection:**		
	Hazardous waste site investigation	GIS	NTIA/Terrestrial
	Ground mapping of ecosystems	GIS	NTIA/Terrestrial
	Oil spill tracking and cleanup	GIS	NTIA/Terrestrial
	Precise location of stored hazardous materials	GIS	NTIA/Surveying

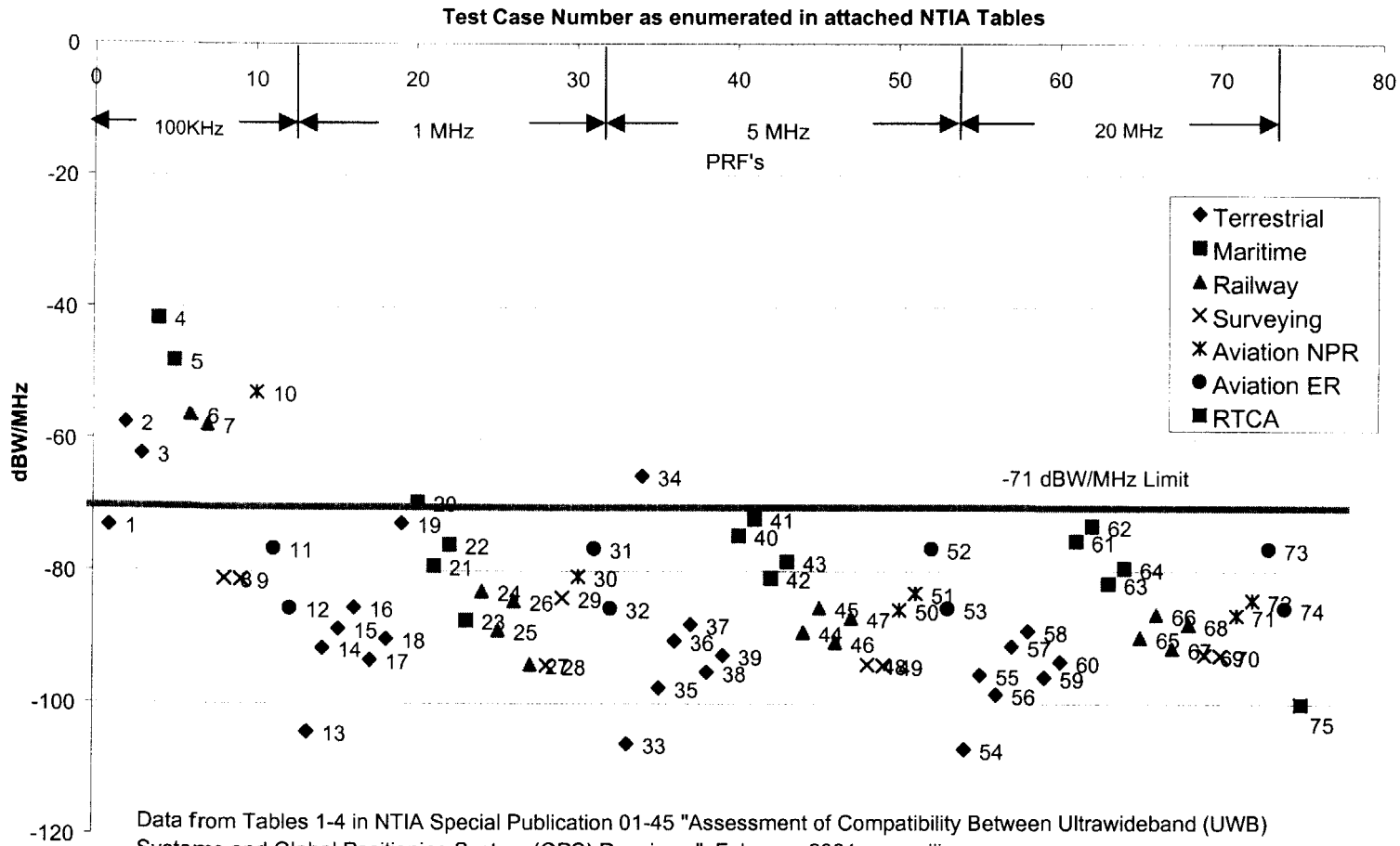
6	**Highway and Construction:**		
	Intelligent vehicle-highway system operation	Public Safety	NTIA/Terrestrial
	Highway facility inventory & maintenance	GIS	NTIA/Terrestrial
	Accident location studies	GIS	NTIA/Terrestrial
	Navigation for motor vehicle drivers	Not addressed in NTIA	
	Truck fleet on-the-road management	Not addressed in NTIA	
	Monitoring status of bridges	Not addressed in NTIA	NTIA/Surveying
7	**Law Enforcement and Legal Services:**		
	Tracking and recovering stolen vehicles	Public Safety, emergency response vehicles	NTIA/Terrestrial
	Tracking narcotics and contraband movements	Not addressed in NTIA	NTIA/Terrestrial
	Maintaining security of high government officials and dignitaries while travelling	Not addressed in NTIA	NTIA/Terrestrial
	Border surveillance	Not addressed in NTIA	NTIA/Terrestrial
	Tort claim evidence in aviation and maritime accidents	Surveying	NTIA/Surveying
	Measuring and recording property boundaries	GIS/Surveying	NTIA/Surveying
8	**Maritime & Waterways:**		
	Navigation on the high seas	Maritime	NTIA/Maritime
	Search and rescue	Maritime	NTIA/Maritime
	All weather harbour approach navigation	Maritime	NTIA/Maritime
	Vessel traffic services	Maritime	NTIA/Maritime
	Dredging of harbours and waterways	Maritime	NTIA/Maritime
	Positioning of buoys and marien navigation aids	Maritime	NTIA/Maritime
	Navigation for recreational vessels	Maritime	NTIA/Maritime
	Location of commercial fishing traps and gear	Maritime	NTIA/Maritime
	Offshore drilling research	Surveying	NTIA/Surveying
	Monitoring deflections in dams as a result of hydrostatic and thermal stress changes	Surveying	NTIA/Surveying
	Ice breaking and monitoring icebergs and flows	Maritime	NTIA/Maritime
	Observing tides and currents	Maritime	NTIA/Maritime
	Harbour facility management	Surveying	NTIA/Surveying
	Location of containers in marine terminals	Not addressed in NTIA	NTIA/Terrestrial

9	**Public Transportation:**		
	Bus fleet on the road management	Not addressed in NTIA	NTIA/Terrestrial
	Passenger and operator security monitoring	Public Safety	NTIA/Terrestrial
10	**Railroad:**		
	Railroad fleet management	Railroad	NTIA/Railroad
	Train control and collision avoidance	Railroad	NTIA/Railroad
	Facility inventory control and management	Railroad	NTIA/GIS
11	**Recreation:**		
	Hiking & mountain climbing	Not addressed in NTIA	Not addressed in NTIA
	Measuring at sports events	Not addressed in NTIA	Not addressed in NTIA
	Setting lines on sports fields	Not addressed in NTIA	Not addressed in NTIA
12	**Surveying:**		
	Electronic bench marker providing absolute reference of latitude, longitude, and altitude	Surveying	NTIA/Surveying
	High precision surveys in minutes by anyone	Surveying	NTIA/Surveying
	Real-time dam deformation monitoring	Surveying	NTIA/Surveying
	Hydrographic surveying	Surveying	NTIA/Surveying
	Efficient and accurate photo surveys	Surveying	NTIA/Surveying
	Measuring areas without triangulation	Surveying	NTIA/Surveying
	Oil and mineral prospecting	Surveying	NTIA/Surveying
	National spatial data infrastructure	Surveying	NTIA/Surveying
13	**Telecommunications**		
	Precise timing for interlacing messages/network synchronization	Not addressed in NTIA	Not addressed
14	**Weather, Scientific and Space**		
	Use as weather balloon position radiosonde	Not addressed in NTIA	Not addressed
	Measurement of sea level from satellites	Not addressed in NTIA	Not addressed
	Navigating and controlling space shuttles	Not addressed in NTIA	Not addressed
	Placing satellites into orbit	Not addressed in NTIA	Not addressed
	Monitoring earthquakes and tectonic plates	Surveying	NTIA/Surveying
	Measuring ground subsidence (sinking)	Surveying	NTIA/Surveying
	Measuring atmospheric humidity from ground	Not addressed in NTIA	Not addressed
	Precise global mapping of ionosphere	Not addressed in NTIA	Not addressed

CPM Reference: Conference Preparatory Meeting Report on Technical, Operational, and Regulatory/Procedural Matters to be Considered by the 2000 World Radiocommunication Conference; 11.25.99, Geneva.

ATTACHMENT 2

FIGURE 1: UWB Interference to GPS Applications with Test Case Number



Data from Tables 1-4 in NTIA Special Publication 01-45 "Assessment of Compatibility Between Ultrawideband (UWB) Systems and Global Positioning System (GPS) Receivers" February 2001 pp. x-xiii

Table 1. Summary of Analysis Results (PRF = 100 kHz)

	Operational Scenario Description					UWB Signal Characteristics			GPS Receiver Architecture	Classification of Interfering Signal	Maximum Interference Threshold (dBW/MHz)	Maximum Allowable EIRP (dBW/MHz)	Comparison with the Current Part 15 Level (dB)
	GPS Application	UWB Single	UWB Multiple	UWB Indoor	UWB Outdoor	PRF (MHz)	Gating %	Mod.					
1	Terrestrial	X			X	0.1	100	None	C/A-code	Pulse-Like	-112.6	-73.2	1.9
2	Terrestrial		X	X		0.1	100	None	C/A-code	Pulse-Like	-112.6	-57.6	-13.7
3	Terrestrial		X		X	0.1	100	None	C/A-code	Pulse-Like	-112.6	-62.3	-9
4	Maritime		X	X		0.1	100	None	C/A-code	Pulse-Like	-112.6	-41.7	-29.6
5	Maritime		X		X	0.1	100	None	C/A-code	Pulse-Like	-112.6	-48.1	-23.2
6	Railway		X	X		0.1	100	None	C/A-code	Pulse-Like	-112.6	-56.3	-15
7	Railway		X		X	0.1	100	None	C/A-code	Pulse-Like	-112.6	-57.8	-13.5
8	Surveying	X			X	0.1	20	2% Rel.	Semi-Codeless	Noise-Like	-138	-81.1	9.8
9	Surveying		X		X	0.1	20	2% Rel.	Semi-Codeless	Noise-Like	-138	-81.2	9.9
10	Aviation-NPA		X		X	0.1	100	None	C/A-code	Pulse-Like	-112.6	-52.9	-18.4
11	Aviation-ER		X	X		Note 1	Note 1	None	C/A-code	Noise-Like	-134.8	-76.6[2]	5.3
12	Aviation-ER		X		X	Note 1	Note 1	None	C/A-code	Noise-Like	-134.8	-85.6[2]	14.3

Notes: En-Route Navigation (ER), Non-Precision Approach (NPA)
1. In this operational scenario, it is assumed that there is a large enough number of UWB devices such that independent of the individual UWB signal parameters, the aggregate effect causes noise-like interference.
2. This maximum allowable EIRP is based on an assumed density of 200 UWB devices per square kilometer transmitting simultaneously.

Table 2. Summary of Analysis Results (PRF = 1 MHz)

	Operational Scenario Description					UWB Signal Characteristics			GPS Receiver Architecture	Classification of Interfering Signal	Maximum Interference Threshold	Maximum Allowable EIRP	Comparison with the Current Part 15 Level (dB)
	GPS Application	UWB Single	UWB Multiple	UWB Indoor	UWB Outdoor	PRF (MHz)	Gating %	Mod.					
13	Terrestrial	X			X	1	100	None	C/A-code	CW-Like	-145.7	-104.3	3.1
14	Terrestrial	X			X	1	100	2% Rel.	C/A-code	Pulse-Like	-131	-91.6	10.3
15	Terrestrial		X	X		1	100	None	C/A-code	CW-Like	-145.7	-88.7	17.4
16	Terrestrial		X	X		1	20 & 100	Multiple	C/A-code	Noise-Like	-134.5	-85.5	14.2
17	Terrestrial		X		X	1	100	None	C/A-code	CW-Like	-145.7	-93.4	22.1
18	Terrestrial		X		X	1	20 & 100	Multiple	C/A-code	Noise-Like	-134.5	-90.2	18.9
19	Maritime		X	X		1	100	None	C/A-code	CW-Like	-145.7	-72.8	1.5
20	Maritime		X	X		1	20 & 100	Multiple	C/A-code	Noise-Like	-134.5	-69.6	-1.7
21	Maritime		X		X	1	100	None	C/A-code	CW-Like	-145.7	-79.2	7.9
22	Maritime		X		X	1	20 & 100	Multiple	C/A-code	Noise-Like	-134.5	-76	4.7
23	Railway		X	X		1	100	None	C/A-code	CW-Like	-145.7	-87.4	16.1
24	Railway		X	X		1	20 & 100	Multiple	C/A-code	Noise-Like	-134.5	-83.9	13.7
25	Railway		X		X	1	100	None	C/A-code	CW-Like	-145.7	-88.5	17.6
26	Railway		X		X	1	20 & 100	Multiple	C/A-code	Noise-Like	-134.5	-84.5	14.2
27	Surveying	X			X	1	100	50% Abs	Semi-Codeless	Noise-Like	-151	-94.1	22.8
28	Surveying		X		X	1	100	50% Abs	Semi-Codeless	Noise-Like	-151	-94.2	22.9
29	Aviation-NPA		X		X	1	100	None	C/A-code	CW-Like	-145.7	-44	12.7
30	Aviation-NPA		X		X	1	20 & 100	Multiple	C/A-code	Noise-Like	-134.5	-50.8	5.5
31	Aviation-ER		X	X		Note 3	Note 3	Note 2	C/A-code	Noise-Like	-134.8	-76.6'	5.3
32	Aviation-ER		X		X	Note 2	Note 2	Note 2	C/A-code	Noise-Like	-134.8	-85.6'	14.3

Notes: En-Route Navigation (ER), Non-Precision Approach (NPA)
1. When the interference effect has been classified as pulse-like or noise-like, the value is expressed in units of dBW/MHz. The value is expressed in units of dBW when the interference effect has been classified as CW-like.
2. In this operational scenario, it is assumed that there is a large enough number of UWB devices, such that independent of the individual UWB signal parameters the aggregate effect causes noise-like interference.
3. The maximum allowable EIRP is based on an assumed density of 200 UWB devices per square kilometer transmitting simultaneously.

Table 3. Summary of Analysis Results (PRF = 5 MHz)

	Operational Scenario Description					UWB Signal Characteristics			GPS Receiver Architecture	Classification of Interfering Signal	Maximum Interference Threshold	Maximum Allowable EIRP	Comparison with the Current Part 15 Level (dB)
	GPS Application	UWB Single	UWB Multiple	UWB Indoor	UWB Outdoor	PRF (MHz)	Gating %	Mod.					
33	Terrestrial	X			X	5	100	None	C/A-code	CW-Like	-145.5	-106.1	74.6
34	Terrestrial	X			X	5	25	50% Abs.	C/A-code	Pulse-Like	-145	-85.6	53
35	Terrestrial	X			X	5	800	50% Abs.	C/A-code	Noise-Like	-137	-97.9	26.3
36	Terrestrial		X	X		5	100	None	C/A-code	CW-Like	-145.5	-90.5	9.2
37	Terrestrial		X	X		5	100	50% Abs.	C/A-code	Noise-Like	-153	-88	6.7
38	Terrestrial		X		X	5	100	None	C/A-code	CW-Like	-145.5	-95.2	23.0
39	Terrestrial		X		X	5	100	50% Abs.	C/A-code	Noise-Like	-153	-92.7	23.4
40	Maritime		X	X		5	100	None	C/A-code	CW-Like	-145.5	-74.6	3.1
41	Maritime		X	X		5	100	50% Abs.	C/A-code	Noise-Like	-153	-72.1	0.8
42	Maritime		X		X	5	100	None	C/A-code	CW-Like	-145.5	-81	9.7
43	Maritime		X		X	5	100	50% Abs.	C/A-code	Noise-Like	-153	-78.5	7.1
44	Railway		X	X		5	100	None	C/A-code	CW-Like	-145.5	-89.2	13.0
45	Railway		X	X		5	100	50% Abs.	C/A-code	Noise-Like	-153	-85.5	14.7
46	Railway		X		X	5	100	None	C/A-code	CW-Like	-145.5	-98.7	19.4
47	Railway		X		X	5	100	50% Abs.	C/A-code	Noise-Like	-153	-87.0	15.7
48	Surveying	X			X	5	20 & 100	50% Abs.	Semi-Codeless	Noise-Like	-151	-94.1	23.8
49	Surveying		X		X	5	20 & 100	50% Abs.	Semi-Codeless	Noise-Like	-151	-94.2	23.9
50	Aviation-NPA		X		X	5	100	None	C/A-code	CW-Like	-145.5	-85.8	14.5
51	Aviation-NPA		X		X	5	100	50% Abs.	C/A-code	Noise-Like	-157	-83.5	12
52	Aviation-ER		X	X		Note 2	Note 2	Note 2	C/A-code	Noise-Like	-134.8	-76.6	5.3
53	Aviation-ER		X		X	Note 2	Note 2	Note 2	C/A-code	Noise-Like	-134.8	-85.8	14.5

Notes: En-Route Navigation (ER), Non-Precision Approach (NPA)

1. When the interference effect has been classified as pulse-like or noise-like, the value is expressed in units of dBW/MHz. The value is expressed in units of dBW when the interference effect has been classified as CW-like.
2. In this operational scenario, it is assumed that there is a large enough number of UWB devices such that independent of the individual UWB signal parameters the aggregate effect causes noise-like interference.
3. This maximum allowable EIRP is based on an assumed density of 200 UWB devices per square kilometer transmitting simultaneously.

Table 4. Summary of Analysis Results (PRF = 20 MHz)

	Operational Scenario Description					UWB Signal Characteristics			GPS Receiver Architecture	Classification of Interfering Signal	Maximum Interference Threshold	Maximum Allowable EIRP	Comparison with the Current Part 15 Level (dB)
	GPS Application	UWB Single	UWB Multiple	UWB Indoor	UWB Outdoor	PRF (MHz)	Gating %	Mod					
54	Terrestrial	X			X	20	20	OOK	C/A-code	CW-Like	-146.3	-86.9	55.4
55	Terrestrial	X			X	20	20	50% Abs	C/A-code	Pulse-Like	-135	-85.6	54.1
56	Terrestrial	X			X	20	100	50% Abs	C/A-code	Noise-Like	-138	-98.6	67.1
57	Terrestrial		X	X		20	20	OOK	C/A-code	CW-Like	-146.3	-91.3	59
58	Terrestrial		X	X		20	100	50% Abs	C/A-code	Noise-Like	-138	-89	57.7
59	Terrestrial		X		X	20	20	OOK	C/A-code	CW-Like	-146.3	-96	64.7
60	Terrestrial		X		X	20	100	50% Abs	C/A-code	Noise-Like	-138	-93.7	62.4
61	Maritime		X	X		20	20	OOK	C/A-code	CW-Like	-145	-75.4	41.1
62	Maritime		X	X		20	100	50% Abs	C/A-code	Noise-Like	-138	-73.1	38
63	Maritime		X		X	20	20	OOK	C/A-code	CW-Like	-145	-81.8	47.5
64	Maritime		X		X	20	100	50% Abs	C/A-code	Noise-Like	-138	-79.5	44.2
65	Railway		X	X		20	20	OOK	C/A-code	CW-Like	-145	-90	55.7
66	Railway		X	X		20	100	50% Abs	C/A-code	Noise-Like	-138	-86.5	52.2
67	Railway		X		X	20	20	OOK	C/A-code	CW-Like	-145	-91.5	58.2
68	Railway		X		X	20	100	50% Abs	C/A-code	Noise-Like	-138	-88.0	54.7
69	Surveying	X			X	20	100	50% Abs & 2% Rel	Semi-Codeless	Noise-Like	-149.5	-92.6	21.3
70	Surveying		X		X	20	100	50% Abs & 2% Rel	Semi-Codeless	Noise-Like	-149.5	-92.7	21.4
71	Aviation-NPA		X		X	20	20	OOK	C/A-code	CW-Like	-145	-86.6	15.3
72	Aviation-NPA		X		X	20	100	50% Abs	C/A-code	Noise-Like	-138	-84.3	13
73	Aviation-ER		X	X		Note 2	Note 2	Note 2	C/A-code	Noise-Like	-134.8	-30.6[3]	5.3
74	Aviation-ER		X		X	Note 2	Note 2	Note 2	C/A-code	Noise-Like	-134.8	-85.6[3]	14.3

Notes: En-Route Navigation (ER), Non-Precision Approach (NPA)

1. When the interference effect has been classified as pulse-like or noise-like, the value is expressed in units of dBW/MHz. The value is expressed in units of dBW when the interference effect has been classified as CW-like.
2. In this operational scenario, it is assumed that there is a large enough number of UWB devices, such that independent of the individual UWB signal parameters the aggregate effect causes noise-like interference.
3. This maximum allowable EIRP is based on an assumed density of 200 UWB devices per square kilometer transmitting simultaneously.