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October 16, 2000

Ms. Magalie Roman Salas
Secretary
Federal Communications Commission
445 12th St., S.W.
Washington, DC 20554

Re: ***Ex Parte* Notification**
ET Docket No. 98-153
Ultra-Wideband

Dear Ms. Salas:

This is to note that on October 17, 2000, Rachel Reinhardt and Michal Freedhoff of Time Domain Corporation, Phillip Inglis, and I met with David Means and Greg Czumak of the Technical Research Branch of the Office of Engineering and Technology. We were joined by telephone by John Reed of OET's Technical Rules Branch.

We discussed the testing efforts underway to examine the interaction of ultra-wideband signals with other systems. As part of these discussions we provided Mr. Means with a copy of Time Domain's comments on the Stanford-Department of Transportation testing, which have been previously submitted to the Commission in this proceeding. We also discussed the NTIA testing efforts. Mr. Means said that he had earlier seen Time Domain's comments on the NTIA testing programs, copies of which Time Domain has previously filed in this proceeding and which are available on the NTIA web site. We also encouraged the FCC staff in their ongoing efforts at dialog with NTIA staff over testing efforts.

We noted in our meeting that Time Domain continues to question the approach of injecting Gaussian noise into the subject receiver, reducing the level of noise by 2 dB, and then injecting the UWB signal for to do so would not offer a reasonable assessment of the effects of UWB alone. We also noted the need to account for antenna effects as well as the need to take into account the noise figure of the GPS receiving system in cases where the system involved an antenna and a preamplifier. In such cases, because of the noise contribution of the pre-amp, we explained that it would not be sufficient simply to adjust for antenna gain alone. With regard to the examination of the impact of UWB energy in the IF stage of the tested receivers, we noted that such an examination alone would be insufficient to provide adequate insight into the effects of UWB on the receiver's performance if this solely e were the focus of the analysis. Instead, any such examination should also take into account any processing gain and digital signal processing capabilities of the receiver. We explained that we understood the desirability of finding ways to employ commercial-off-the-shelf test equipment in the evaluation of UWB emissions but emphasized that the use of such equipment and the development of correction factors required great care to be sure that the readings taken could be equated to the standards set forth in the rules. In order to illustrate the need to understand the interaction of pulsed emissions with the measurement instrumentation we showed spectrum graphs that depicted how different detector and resolution bandwidth functions in spectrum analyzers responded to pulses of various pulse repetition rates.

We also explained the importance of recognizing that the emission levels set for UWB signals in the GPS bands would be taken into consideration as new radio services are developed and emission limits are developed for such services. In this respect, we noted the recent adoption by the Commission of the limit of –70 dBW/MHz for unwanted broadband emissions from public safety transmitters that would operate in the new 700 MHz public safety land mobile band and the earlier adoption of a similar limit for mobile satellite terminals.

Finally, we alluded to GPS-UWB scenarios under development by NTIA. We said that Time Domain would shortly be supplying its comments on the scenarios and urged the staff to study the scenarios. We offered the view that many of the scenarios unrealistically depicted the proximity of UWB, the performance of GPS, and the likely application of UWB. Today, a copy of those scenarios was submitted to Messrs. Means, Czumak and Reed via email. The copy as submitted is enclosed.

Should any questions arise concerning this matter, please contact me.

Respectfully,

/s/ David E. Hilliard

David E. Hilliard
Counsel for Time Domain Corporation

cc: (w/ enclosures) Messrs. Means, Czumak, and Reed

Time Domain Corporation
7057 Old Madison Pike
Huntsville, AL 35806
256-922-9229

July 24, 2000

Department of Transportation
Office of the Secretary
Radionavigation & Positioning Staff, P-7, Room 10315
400 Seventh Street, S.W.
Washington, D.C. 20590
Attn: GPS-UWB Comments

Re: Ultra-Wideband Testing by DoT

Dear Radionavigation & Positioning Staff Members:

Time Domain Corporation respectfully submits these comments on the testing plan prepared by personnel from Stanford University entitled *Potential Interference to GPS from UWB Transmitters, Test Plan - Version 4.5* (the "Stanford Plan")[1] in response to the invitation extended in the Public Notice of June 22, 2000, 65 FR 38874. Because of the importance of Global Positioning System (GPS) applications and the promise of ultra-wideband (UWB) technologies, the Federal Communications Commission expects to receive the test results it asked to be conducted by October 30, 2000. To aid the FCC in reaching sound UWB implementation decisions, the testing that DoT has proposed must be carried out in a scientifically rigorous and objective manner.

Summary

The Stanford Plan is fundamentally flawed and will not provided meaningful assessment of potential interference:

- The plan does not provide for any correlation to real world environments (e.g., ambient noise levels) nor does it compare intentional and unintentional UWB interference.
- The plan tries to equate all UWB signals with "white" noise.

[1] For ease of reference, a version of the Stanford Plan with line numbers in the margin is provided with these comments. The citations in these comments reference that version.

- The plan does not propose to test a signal such as that produced by Time Domain's and other's equipment.

- The plan proposes to subject the white noise signal to filtering prior to injecting it into the GPS receiver, but does not propose to route the UWB signal through the same sort of filter.

- The plan offers no justification for its one second reacquisition criterion for land based receivers.

- The plan fails to state that the testing will be conducted using a GPS simulator operating with a realistic constellation of satellites, giving rise to the presumption that the evaluation will examine the effect of UWB on only one satellite signal that will have been adjusted to a received power of less than 4 dB above the thermal noise floor – hardly a realistic scenario.

- The plan exhibits a clear bias by arguing that any margin has already been consumed by the –70 dBW/MHz out-of-band emissions limit applicable to mobile satellite transceivers; by crippling the GPS link with high levels of noise; and then testing for the impact of UWB.

Unless these deficiencies are corrected, the Stanford Plan will not yield the sort of information that will assist the FCC in reaching sound decisions concerning the implementation of UWB technology.

Overview

Both the overall assumptions and the design of the Stanford Plan rest on the foregone conclusion that there will be harmful interference and that this effort ensures that this is the case. The Stanford Plan, for example, devotes a substantial amount of text to arguing that the -70 dBW/MHz out-of-band signal level applicable to Mobile Satellite Service (MSS) transceivers consumes any margin that may exist. This argument is misplaced. While GPS proponents may assert – as they have in other FCC proceedings – that the -70 dBW/MHz level should not apply in the case where other emissions fall into GPS spectrum, this testing effort involves assessing the impact of UWB emissions, not MSS transceiver emissions.

The testing should examine the actual impact of UWB signals on GPS receivers, but does not. To begin with, the plan proposes to correlate broadband noise with UWB signals, while choosing to only filter the broadband noise signals. This unequal filtering approach will likely show a reduced impact of broadband noise, as compared to UWB. Even assuming that such a comparison is appropriate, one cannot conclude that the broadband noise signal introduced as a comparison signal will resemble the GPS ambient environment or an actual white noise source as the plan suggests. Moreover, the Stanford Plan offers no confirmation that the proposed broadband noise signal resembles the actual ambient environment in which GPS systems operate. It is possible that UWB emissions will interact differently with actual noise signals in the GPS band . Therefore, at a minimum, a better approach would be to characterize the interference effects from the broadband noise source separately from the UWB signal source – by testing each separately. Further, the Stanford Plan's total reliance on simulator testing fails to afford any check on the assumptions that underlie the proposed testing. As one example, the Plan does not make clear whether the simulator consists of more than a single channel receiver. To the extent that the GPS simulator attempts to approximate a typical GPS receiver, it must include more than a single channel, for a typical GPS system receives eight or more satellite signals. For these and the other reasons discussed below, the plan should be revised if it is to have scientific value.

The Need for Real-World Testing and Verification

The Stanford Plan is aimed at collecting data based on worst case scenarios (*see* Stanford Plan page 3, lines 17-44; page 2, lines 39-42) not likely to be encountered in real world operating conditions. It does not include any "over the air" tests of the potential interference caused by radiated UWB transmitters – the only way that interference can actually occur. All of the testing will be performed in a laboratory environment, by directly connecting the UWB and noise sources to the input of a GPS receiver. While the use of a GPS signal simulator provides the control needed to isolate variables, radiated emissions testing is needed to quantify adequately the true impact on GPS receivers and to validate (and where necessary, modify) the laboratory configurations. For example, the laboratory tests must sufficiently model the radiated effects of both GPS and UWB antennas, as antenna effects can significantly impact test measurements. Another example of major factors in typical GPS links is multipath.

The theoretical foundation of the Stanford Plan is suspect. The Plan states that the GPS Receiver RFI Susceptibility Limit is -170.1 dBm/Hz – only 3.9 dB higher than the thermal noise floor of -174 dBm/Hz. At this level, all FCC Part 15 compliant Class A and B digital devices (*e.g.,* computers, radio receivers and intentional radiators) as well as a host of incidental radiators (*e.g.,* motor-driven appliances) will have to be turned off within restricted areas of operation, such as in and around airports. If the -170.1 dBm/Hz GPS Receiver Susceptibility Limit had a relation to real-world impact, one would expect to find that GPS Systems would already have difficulty operating – regardless of UWB equipment. Moreover, there are a number of other RF systems that are legally permitted to radiate even higher powered signals within the GPS bands, including out-of-band and spurious emissions from TV stations, land mobile communications systems, and ISM equipment.

Applying the test results from the Stanford Plan, in its current form, to the development of protection criteria will therefore be misleading. This test plan, like any scientific study, should focus on a single variable at a time while maintaining constant other factors. Following this scientific principle, the test plan should analyze only the impact of UWB transmitters on GPS receivers.

Further, the test plan states that the entire 5.6 dB margin is consumed by other aeronautical services (*see* page 4, line 7). This leaves no margin for UWB signals. The Stanford Plan asserts the pre-conceived bias that the Mobile Satellite Services (MSS) 1610-1626.5 MHz (earth-to-space) band alone prevents UWB from existing with GPS systems. Time Domain questions the use of such an assumption. The title of this study as published in the Federal Register is "Test Plan for Determining the Potential for Interference from UWB to GPS Receivers," 65 FR 38874 (June 22, 2000). MSS and other emitters should not be a factor at this stage of the testing. Other systems properly come into play when analyzing a real-world scenario, which, as Time Domain has already noted, includes the effects of ambient noise interference, which includes other RF systems.

Consider another example of attempting to equate theoretical design parameters with real-world impact. The Stanford Plan contemplates using GPS reacquisition performance, a "critical performance metric" for "real-time land applications," to quantify the impact of UWB transmissions. *See* page 3, lines 1-6; *see also* page 8, lines 33-37. However, the Stanford Plan fails to explain how the one second reacquisition performance metric was derived other than to say that the one second figure rests on the authors assumptions as to land operating scenarios. *See* page 8, lines 33-37; page 11, lines 1-3. It is unclear whether any study was conducted to determine the adequacy of such a metric. In fact, one commonly available GPS land receiver we encountered specified a 15 second warm-start acquisition time and a 45 second cold-start acquisition time. Furthermore, emergency response vehicles and in-vehicle navigation systems are designed to deal with signal lock loss (hence the genesis of the "reacquisition" performance metric) caused by a number of factors, including environmental obstructions. If a UWB transmitter is not on-board the vehicle and operating in a manner that couples into the external GPS antenna, any impact on signal reacquisition will be transitory as the vehicle moves. The vehicle would likely be out of any zone of potential UWB interference in under a second. In any event, GPS systems are designed to deal with – and do deal with – these situations on a regular basis.

The Stanford Plan also appears to have made an assumption that, at this stage of the testing, it is only worth considering the reacquisition parameter in connection with land operation. Once the time has been expended to configure a test setup, taking measurements of pseudo-range accuracy, initial acquisition time and carrier phase data (*see* page 8, lines 26-27) would be relatively simple tasks and would likely yield additional useful data points.

Not All UWB Signals Can Be Equated With Broadband Noise

Curiously, the Stanford Plan states that it "does not define the interference scenarios" (*see* page 6, line 40-42), while at the same time it claims to develop an RFI equivalence concept "to relate the interference impact of UWB signals on GPS" through use of a well-known RFI broadband source. *See* page 6, lines 5-11. The Stanford Plan asserts that it is possible to equate the broadband noise power with UWB transmitter power. *See* page 6, at lines 36-39 ("if during the broadband noise equivalence test, a 4 dB increase in broadband noise also corresponds to a 4 dB increase in UWB transmitter power, for the same accuracy degradation value (15 cm) then UWB source may be classified as noise like."). Before conducting the procedure to determine equivalence of UWB with broadband noise (*see* page 6, lines 12-22), it makes sense to determine if there exists a linear relationship between the broadband noise and UWB sources, *i.e.,* can one be used as an adequate replacement of the other. (Item 3 on page 6, at lines 36-39, presupposes a linear relationship.) The existence of such a relationship, on which much of this testing depends, can potentially be determined by first finding the UWB source level that causes 15 cm of deviation, then decreasing it by 2 dB, and replacing the UWB source with broadband noise to cause the same 15 cm deviation. If more or less than a 2 dB compensation level is needed, then the relationship between the two sources is not linear and a new analysis criteria must be developed. Nonetheless, even if the result here showed equal compensation levels, use of such a test configuration is questionable in light of the different methods of measuring UWB transmitter power levels. A better approach would be to characterize the interference effects of each source separately.

It is only possible to classify as noise-like some UWB transmitters, *i.e.,* randomly time-dithered sources in bandwidths narrower than the pulse repetition frequency (PRF). Because the methods of quantifying UWB signals are still under question, the modeling approach in the Stanford Plan rests on several still undetermined grounds, again stressing the need for real-world testing to adequately quantify effects on GPS systems as measured in a laboratory. It simply cannot be assumed that the laboratory assumptions and conditions are accurately modeling reality; these assumptions must be validated with "over-the-air" testing.

Indeed, all interference effects measured by the Stanford Plan will be in combination with broadband noiseWhen coupling an UWB signal and broadband noise, the testing will show more interference potential than analyzing the UWB source alone. White noise can have peaks of up to 14 dB which can make it difficult to quantify the isolated impact of UWB.

The Plan states that the broadband noise source will be used to not only correlate the impact of UWB emissions to white noise, but that it is intended to be representative of "the actual GPS environment." *See* page 6, lines 10-11; *see also* page 8, lines 13-19. As Time Domain has stated above, the other RF signals that are present in the GPS band do not appear to be white noise-like, and therefore this assumption is likely invalid. Additionally, the Stanford Plan provides no justification of why the noise source is filtered and the UWB source is not.

Moreover, the Stanford Plan discusses measuring noise power and total noise power without delineating the technique used. *See* page 11, line 28-31; page 13, lines 20-26, line 34-36; page 15, lines 27-34, 43-45; page 16, lines 17-21. The method of measuring noise levels is a critical factor – and with regard to UWB technology, an open issue. In any event, the method used must be delineated, *e.g.,* spectrum analyzer, power meter, peak power levels, average RMS levels.

In sum, the Stanford Plan makes no attempt to address the actual impact of UWB emissions on GPS receiver performance. Instead of using a model based on the existing environmental levels of ambient background signals, the Plan uses a filtered noise source operated at levels sufficient to cause GPS receiver errors. The Stanford Plan should be revised to include real-world testing to verify the assumptions inherent in the simulator testing. The testing configuration should measure the UWB signal level required to produce interference in GPS systems as a function of variations in the existing ambient noise levels with the GPS system receiving actual satellite signals. We strongly recommend that the DoT review the GPS susceptibility test plan developed the Applied Research Laboratory, the University of Texas as an example of a test plan based on scientific principles.

Sincerely,
Time Domain Corporation

/s/

Paul Withington
Vice-President for Standards & Testing

Enclosure: (Stanford Plan)

PUBLIC SAFETY APPLICATIONS[1]							
Minimum Distance Separation Between GPS and Receiver and UWB Transmission System(s)	**Propagation Model**	**GPS Receiver Antenna Location**	**GPS Receiver Antenna Gain**	**Safety Margin**	**Additional Scenario Dependent Factors**	**Number of UWB Transmission Systems**	**Activity Factor of the UWB Transmission Systems**
1. GPS Receiver Application: GPS Receiver in a Cellular Phone for Mobile E911 Position Location **UWB Transmission System Application:** UWB Transmission System Embedded in a Cellular Phone							
2 m	Free Space	Same height as UWB transmission system	0 dBic	N/A	N/A	1	100%
2. GPS Receiver Application: GPS Receiver in a Cellular Phone for Mobile E911 Position Location **UWB Transmission System Application:** Indoor UWB Transmission System Local Area Network							
2 m for all UWB transmission systems	Free Space	Same height as UWB transmission systems	0 dBic	N/A	Building attenuation of 9 dB[2]	10	?
3. GPS Receiver Application: GPS Receiver in a Cellular Phone for Mobile E911 Position Location **UWB Transmission System Application:** Outdoor UWB Transmission System Local Area Network							
2 m for all UWB transmission systems	Free Space	Same height as UWB transmission systems	0 dBic	N/A	N/A	10	?
4. GPS Receiver Application: GPS Receiver in an Emergency Response Vehicle (Police, Fire, Ambulance) **UWB Transmission System Application:** UWB Transmission System Embedded in a Cellular Phone							
2 m	Free Space	Mounted on the roof of the vehicle	-4.5 dBic	N/A	N/A	1	100%
5. GPS Receiver Application: GPS Receiver in an Emergency Response Vehicle (Police, Fire, Ambulance) **UWB Transmission System Application:** Indoor UWB Transmission System Local Area Network							

[1] U.S. GPS Industry Council Submission to NTIA GPS/UWB Operational Scenario Meeting on September 7, 2000. This document is available on NTIA's website <http://www.ntia.doc.gov/osmhome/uwbtestplan/mtg090700_files/>.

[2] U.S. Department of Commerce, National Telecommunications and Information Administration, NTIA Report 95-325, *Building Penetration Measurements From Low-Height Base Stations at 912 MHz, 1920 MHz, and 5990 MHz* (May 1992) at 43.

2 m for all UWB transmission systems	Free Space	Mounted on the roof of the vehicle	-4.5 dBic	N/A	Building Attenuation of 9 dB	10	?
6. GPS Receiver Application: GPS Receiver in an Emergency Response Vehicle (Police, Fire, Ambulance) **UWB Transmission System Application:** Outdoor UWB Transmission System Local Area Network							
2 m for all UWB transmission systems	Free Space	Mounted on the roof of the vehicle	-4.5 dBic	N/A	N/A	10	?
7. GPS Receiver Application: GPS Receiver in an Emergency Response Vehicle (Police, Fire, Ambulance) **UWB Transmission System Application:** One UWB Transmission System Embedded in a Cellular Phone and One UWB Transmission System in a Laptop Computer. Both UWB Transmission Systems Located Inside the Emergency Vehicle							
1 m for both UWB Transmission Systems	Free Space	Mounted on the roof of the vehicle	-4.5 dBic	N/A	x dB of Attenuation Through the Roof of the Vehicle	2	?
GEOGRAPHIC INFORMATION SYSTEM (GIS) APPLICATIONS[3]							
8. GPS Receiver Application: Mobile GPS Receiver GIS Data Recorder **UWB Transmission System Application:** UWB Transmission System Embedded in a Cellular Phone							
2 m	Free Space	Mounted on the roof of the vehicle	-4.5 dBic	N/A	N/A	1	100%
9. GPS Receiver Application: Mobile GPS Receiver GIS Data Recorder **UWB Transmission System Application:** Indoor UWB Transmission System Local Area Network							
2 m for all UWB transmission systems	Free Space	Mounted on the roof of the vehicle	-4.5 dBic	N/A	Building Attenuation of 9 dB	10	?
10. GPS Receiver Application: Mobile GPS Receiver GIS Data Recorder **UWB Transmission System Application:** Outdoor UWB Transmission System Local Area Network							
2 m for all UWB transmission systems	Free Space	Mounted on the roof of the vehicle	-4.5 dBic	N/A	N/A	10	?
11. GPS Receiver Application: Mobile GPS Receiver GIS Data Recorder **UWB Transmission System Application:** One UWB Transmission System Embedded in a Cellular Phone and One UWB Transmission System in a Laptop Computer. Both UWB Transmission Systems Located Inside the Emergency Vehicle							

[3] U.S. GPS Industry Council Submission to NTIA GPS/UWB Operational Scenario Meeting on September 7, 2000. This document is available on NTIA's website <http://www.ntia.doc.gov/osmhome/uwbtestplan/mtg090700_files/>.

1 m for both UWB Transmission Systems	Free Space	Mounted on the roof of the vehicle	-4.5 dBic	N/A	X dB of attenuation through the roof of the vehicle	2	?
PRECISION MACHINE CONTROL APPLICATIONS[4]							
12. GPS Receiver Application: GPS Receiver Used for the Precision Control of Construction Equipment **UWB Transmission System Application:** UWB Transmission System Embedded in a Cellular Phone							
2 m	Free Space	Mounted on the roof of the construction equipment	0 dBic	N/A	N/A	1	100%
13. GPS Receiver Application: GPS Receiver Used for Precision Control of Construction Equipment **UWB Transmission System Application:** Indoor UWB Transmission System Local Area Network							
10 m for all UWB transmission systems	Free Space	Mounted on the roof of the construction equipment	0 dBic	N/A	Building Attenuation of 9 dB	10	?
14. GPS Receiver Application: GPS Receiver Used for Precision Control of Construction Equipment **UWB Transmission System Application:** Outdoor UWB Transmission System Local Area Network							
10 m for all UWB transmission systems	Free Space	Mounted on the roof of the vehicle	0 dBic	N/A	N/A	10	?
MARITIME APPLICATIONS[5]							
15. GPS Receiver Application: GPS Receiver used for Navigation in Constricted Waterways (Shore-Shore Navigation) **UWB Transmission System Applications:** UWB Transmission System Embedded in a Cellular Phone							
Horizontal: 125 ft Vertical: 45 ft	Free Space	Mounted on the mast of the vessel	-4.5 dBic	N/A	N/A	1	100 %
16. GPS Receiver Application: GPS Receiver used for Navigation in Constricted Waterways **UWB Transmission System Applications:** UWB Transmission System Embedded in a Cellular Phone							

[4] U.S. GPS Industry Council Submission to NTIA GPS/UWB Operational Scenario Meeting on September 7, 2000. This document is available on NTIA's website <http://www.ntia.doc.gov/osmhome/uwbtestplan/mtg090700_files/>.

[5] U.S. Coast Guard Navigation Center Submission to NTIA GPS/UWB Operational Scenario Meeting on September 27, 2000. This document is available on NTIA's website <http://www.ntia.doc.gov/osmhome/uwbtestplan/mtg090700_files/>.

Horizontal: 170 ft Vertical: 25 ft	Free Space	Mounted on the mast of the vessel	0 dBic	N/A	N/A	1	100%
17. GPS Receiver Application: GPS Receiver used for Harbor Navigation and Inland Waterways **UWB Transmission System Applications:** UWB Transmission System Embedded in a Cellular Phone							
Horizontal: 200 ft Vertical: 25 ft	Free Space	Mounted on the mast of the vessel	0 dBic	N/A	N/A	1	100%
18. GPS Receiver Application: GPS Receiver used for Docking Operations (Approach Channel) **UWB Transmission System Applications:** UWB Transmission System Embedded in a Cellular Phone							
Horizontal: 100 ft Vertical: 25 ft	Free Space	Mounted on the mast of the vessel	-4.5 dBic	N/A	N/A	1	100%
19. GPS Receiver Application: GPS Receiver used for Docking Operations **UWB Transmission System Applications:** UWB Transmission System Embedded in a Cellular Phone							
Horizontal: 50 ft Vertical: 25 ft	Free Space	Mounted on the mast of the vessel	-4.5 dBic	N/A	N/A	1	100%
20. GPS Receiver Application: GPS Receiver used for Navigation Around Bridges **UWB Transmission System Applications:** UWB Transmission System Embedded in a Cellular Phone							
Horizontal: 0 ft Vertical: 15 ft	Free Space	Mounted on the mast of the vessel	3 dBic	N/A	X dB of bridge deck attenuation	1	100%
21. GPS Receiver Application: GPS Receiver used for Lock Operations **UWB Transmission System Applications:** UWB Transmission System Embedded in a Cellular Phone							
Horizontal: 25 ft Vertical: 25 ft	Free Space	Mounted on the mast of the vessel	-4.5 dBic	N/A	N/A	1	100%
SURVEYING APPLICATIONS[6]							
22. GPS Receiver Application: GPS Receiver used for NGS Airport Surveys **UWB Transmission System Applications:** Single UWB Transmission System							
100 ft	Free Space	2 meters below the UWB antenna	0 dBic	N/A	N/A	1	100%
23. GPS Receiver Application: GPS Receiver used for NGS Airport Surveys **UWB Transmission System Applications:** Multiple UWB Transmission Systems							

[6] NOAA/NOS National Geodetic Survey Submission to NTIA GPS/UWB Operational Scenario Meeting on September 27, 2000. This document is available on NTIA's website <http://www.ntia.doc.gov/osmhome/uwbtestplan/mtg090700_files/>.

100 ft one UWB transmission system and between 1000 –2500 ft for the other two UWB transmission systems	Free Space	2 meters below the UWB antennas	0 dBic	N/A	N/A	3	?
AVIATION APPLICATIONS							
24. GPS Receiver Application: GPS Receiver used for En-route Navigation[7] **UWB Transmission System Applications:** Multiple UWB Transmission Systems							
1000 ft	Free Space	On the top of aircraft fuselage	-4.5 dBic	6 dB	5.5 dB shielding from the aircraft	UWB transmission system density of 200/mi^2	?
25. GPS Receiver Application: GPS Receiver used for Non-Precision Approach Landing[8] **UWB Transmission System Applications:** UWB Transmission System Embedded in a Cellular Phone							
170 ft	Free Space	On top of aircraft fuselage above the UWB transmission system	-4.5 dBic	6 dB	5.5 dB shielding from the aircraft	1	100%
26. GPS Receiver Application: GPS Receiver used for Runway Incursion[9] **UWB Transmission System Applications:** UWB Transmission System Embedded in a Cellular Phone							

[7] Document No. RTCA/DO-235, *Assessment of Radio Frequency Interference Relevant to the GNSS* (Jan. 27 1997) at A-2.

[8] Document No. RTCA/DO-235, *Assessment of Radio Frequency Interference Relevant to the GNSS* (Jan. 27 1997) at A-2.

[9] NTIA Submission to NTIA GPS/UWB Operational Scenario Meeting on September 27, 2000. This document is available on NTIA's website <http://www.ntia.doc.gov/osmhome/uwbtestplan/mtg090700_files/>.

<table>
<tr><td>Horizontal[10]:
A/I: 16.25 m
B/II: 21.5 m
C/III: 26 m
D/IV: 40.5 m
E/V: 47.5 m

Vertical:
Based on the height of the aircraft</td><td>Free Space</td><td>On top of aircraft fuselage above the UWB transmission system</td><td>-4.5 dBic</td><td>6 dB</td><td>N/A</td><td>1</td><td>100%</td></tr>
<tr><td colspan="8">27. GPS Receiver Application: GPS Receiver used for Runway Incursion
UWB Transmission System Applications: Network of UWB Transmission Systems Communicating Between Aircraft and Airline Maintenance Operations Personnel</td></tr>
<tr><td>Horizontal:
A/I: 16.25 m
B/II: 21.5 m
C/III: 26 m
D/IV: 40.5 m
E/V: 47.5 m

Vertical:
Based on the height of the aircraft</td><td>Free Space</td><td>On top of aircraft fuselage above the UWB transmission system</td><td>-4.5 dBic</td><td>6 dB</td><td>N/A</td><td>10</td><td>?</td></tr>
</table>

[10] This distance is based on the Object Free Area that is defined in Document No. RTCA/DO-247, *The Role of the Global Navigation Satellite System (GNSS) in Supporting Airport Surface Operations* (Jan. 7, 1999) at 65.