Before the
Federal Communications Commission
Washington, D.C. 20554

In the matter of	)	
	)	
Revision of Part 15 of the Commission's Rules	)	
Regarding Ultra-Wideband Transmission	)	ET Docket No. 98-153
Systems	)	

Memorandum Opinion and Order and Further Notice of Proposed Rule Making

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By the Commission: Chairman Powell and Commissioner Copps issuing separate statements.

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I. INTRODUCTION

1. By this action, we are amending Part 15 of our rules regarding the unlicensed operation of ultra-wideband (UWB) transmission systems. These amendments respond to fourteen petitions for reconsideration that were filed in response to the *First Report and Order* ("*R&O*") in this proceeding.[1] In general, this Memorandum Opinion and Order ("MO&O") does not make any significant changes to the existing UWB technical parameters.[2] We are reluctant to do so until we have more experience with UWB devices. We also believe that any major changes to the rules for existing UWB product categories at this early stage would be disruptive to current industry product development efforts. We have reviewed the requests from the petitioners and are granting those that will not increase the interference potential of UWB devices. We are denying those requests that sought, without factual support, further restrictions on UWB operations. We believe that the next 12 to 18 months should allow the introduction of UWB devices under our recently adopted rules. We also hope that additional tests using commercially available UWB devices will have been completed within that time frame. We understand that such tests currently are being contemplated by the National Aeronautics and Space Administration (NASA), the Department of Transportation (DOT), by the Department of Defense, and by commercial entities. As these steps occur, we intend to continue our review of the UWB standards to determine where additional changes warrant consideration.

2. Based on these petitions, we are amending the rules to facilitate the operation of through-wall imaging systems by law enforcement, emergency rescue and firefighter personnel in emergency situations; we are eliminating the requirement that GPRs and wall imaging systems operate with their -10 dB bandwidths below 960 MHz or above 3.1 GHz; we are clarifying the limitations on who may operate ground penetrating radar (GPR) systems and wall imaging systems and for what purposes; we are eliminating the requirement for non-hand held GPRs to employ a dead man switch; we are clarifying the coordination requirements for imaging devices; and we are clarifying the rules regarding emissions produced by digital circuitry used by UWB transmitters. We also are proposing additional new rules to address issues raised by MSSI and by Siemens regarding the operation of low pulse repetition frequency (PRF) UWB systems, including vehicular radars, in the 3.1-10.6 GHz band; the operation of frequency hopping vehicular radars in the 22-29 GHz band as UWB devices; the establishment of new peak power limits for wideband Part 15 devices that do not operate as UWB devices; and the definition of a UWB device.

II. BACKGROUND

3. On February 14, 2002, the Commission adopted a *First Report and Order* ("R&O") in the above captioned proceeding. This R&O amended Part 15 of our rules to permit the marketing and operation of products incorporating UWB technology. UWB radio systems can employ pulse modulation

[1] *See First Report and Order* in ET Docket No. 98-153, 17 FCC Rcd 7435 (2002). An *Erratum* to the *First Report and* Order was adopted on May 30, 2002. *See Erratum* in ET Docket No. 98-153, 17 FCC Rcd 10505 (2002).

[2] The exception is the establishment of a new limited UWB operation requested by Time Domain.

where extremely narrow (short) bursts of RF energy are modulated and emitted to convey information.[3] Because of the very short duration of these pulses, the emission bandwidths from these systems are large and often exceed one gigahertz.[4] In some cases, "impulse" transmitters are employed where the pulses do not modulate a carrier. Instead, the radio frequency emissions generated by the pulses are applied to an antenna, and the resonant frequency of the antenna determines the center frequency of the radiated emission. The frequency response characteristics of the antenna provide band-pass filtering, further affecting the shape of the radiated signal. UWB devices can be used for precise measurement of distances or locations and for obtaining the images of objects buried under ground or behind surfaces. UWB devices can also be used for wireless communications, particularly for short-range high-speed data transmissions suitable for broadband access to networks.

4. Several categories of UWB devices are permitted under the regulations including imaging systems,[5] vehicular radars and indoor and outdoor communication systems. Because of their wide operating bandwidths, UWB devices operate in frequency bands that are allocated both to U.S. Government and to non-government operations. Operation of Government radio stations is regulated by the National Telecommunications and Information Administration (NTIA), while operation of stations by private industry, by state and local governments and by the public is regulated by the FCC. The standards and operating requirements that we recently adopted were based in large measure on standards that NTIA found to be necessary to protect against interference to vital federal government operations.

5. In the *R&O*, the Commission recognized the benefits that UWB technology offers for Government, public safety, businesses and consumers. However, it also recognized that those substantial benefits might not be realized if UWB devices were to cause interference to licensed services and other important radio operations. Accordingly, the Commission established technical standards and operating restrictions for three types of UWB devices based on their potential to cause interference. These three types of devices are: 1) imaging systems including GPRs, wall imaging systems, through-wall imaging systems, surveillance systems and medical imaging devices; 2) vehicular radar systems; and 3) communications and measurement systems consisting of indoor-only devices and hand held devices that may be operated anywhere. The Commission adopted standards for UWB devices that it believed to be very conservative. The UWB emission limits generally are significantly more stringent than those imposed on other Part 15 devices; outdoor use of UWB devices is limited to imaging systems, vehicular radar systems, and hand held devices; and the frequency bands within which UWB products are permitted to operate are limited. The frequency band of UWB operation is based on the -10 dB bandwidth of the emission.[6] This combination of technical standards and operational restrictions is designed to ensure that UWB devices can coexist with the authorized radio services without the risk of harmful interference while we gain experience with this technology. The following standards and operational restrictions were applied to UWB devices:

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[3] The rules adopted in the *R&O* also permit UWB devices to comply with the minimum bandwidth requirement due to the use of a high speed data rate or the use of other modulation techniques instead of the width of the pulse or impulse signal.

[4] Typical pulse widths used by UWB devices currently are on the order of 0.1-2 nanoseconds, or less, in width. The emission spectrum appears as a fundamental lobe with adjacent side lobes that can decrease slowly in amplitude. The rise time of the leading edge of the pulse and the passband of the radiating antenna are major factors in determining the bandwidth of the UWB emission.

[5] Imaging systems consist of GPRs, wall imaging systems, through-wall imaging systems, surveillance systems, and medical imaging systems.

[6] The -10 dB bandwidth is the frequency band bounded by the points that are 10 dB below the highest level radiated emission, as based on the complete transmission system including the antenna. This bandwidth is defined in the rules as the UWB bandwidth. *See* 47 C.F.R. § 15.503(a).

- ***Imaging Systems***: GPRs and other imaging devices may operate under Part 15 of the Commission's rules subject to certain frequency and power limitations. All imaging systems are subject to coordination with NTIA through the FCC. Coordination may not take longer than 15 business days from the receipt of the coordination request by NTIA, and special temporary authorizations may be expedited when circumstances warrant. The operation of imaging systems in emergencies involving safety of life or property may take place following a notification procedure.[7] The operators of imaging devices, other than medical imaging devices, must be eligible for licensing under Part 90 of our rules. Medical imaging systems must be used at the direction of, or under the supervision of, a licensed health care practitioner. Imaging systems include:

  - ***Ground Penetrating Radar Systems*:** GPRs must be operated with their -10 dB bandwidth below 960 MHz or within the frequency band 3.1-10.6 GHz. GPRs operate only when in contact with, or within close proximity of, the ground for the purpose of detecting or obtaining the images of buried objects. The energy from the GPR is intentionally directed down into the ground for this purpose. Operation is restricted to law enforcement, fire and rescue organizations,[8] to scientific research institutions, to commercial mining companies, and to construction companies.[9]

  - ***Wall Imaging Systems*:** Wall imaging systems must be operated with their -10 dB bandwidth below 960 MHz or within the frequency band 3.1-10.6 GHz. Wall-imaging systems are designed to detect the location of objects contained within a "wall." Typical uses include examining a concrete structure, the side of a bridge, or the wall of a mine. Operation is restricted to law enforcement, fire and rescue organizations, to scientific research institutions, to commercial mining companies, and to construction companies.

  - ***Through-wall Imaging Systems*:** These systems must be operated with their -10 dB bandwidth below 960 MHz or within the frequency band 1.99-10.6 GHz. Through-wall imaging systems detect the location or movement of persons or objects that are located on the other side of a structure such as a wall. Operation is limited to law enforcement, fire and rescue organizations.

  - ***Surveillance Systems*:** These systems must be operated with their -10 dB bandwidth within the frequency band 1.99-10.6 GHz. Surveillance systems operate as "security fences" by establishing a stationary RF perimeter field and detecting the intrusion of persons or objects in that field. Operation is limited to law enforcement, fire and rescue organizations, to public utilities and to industrial entities.[10]

  - ***Medical Systems*:** These devices must be operated with their -10 dB bandwidth within the frequency band 3.1-10.6 GHz. A medical imaging system may be used for a variety

[7] The notification procedure is described in 47 C.F.R. § 2.405(a)-(e).

[8] As used in this MO&O, law enforcement, fire and emergency rescue organizations refers to parties eligible to obtain a license from the FCC under the eligibility requirements specified in 47 C.F. R. § 90.20(a)(1).

[9] As detailed later in this MO&O, the provisions regarding who may operate a GPR and for what purpose were further interpreted in an *Order* adopted on July 12, 2002. *See Order* in ET Docket No. 98-153, 17 FCC Rcd 13522 (2002).

[10] As used in this MO&O, the reference to public utilities and industrial entities refers to the manufacturers licensees, petroleum licensees and power licensees defined in 47 C.F.R. § 90.7.

of health applications to "see" inside the body of a person or animal. Operation must be at the direction of, or under the supervision of, a licensed health care practitioner.

- ***Vehicular Radar Systems*:** Vehicular radars are limited to operation on terrestrial transportation vehicles. The -10 dB bandwidth must be within the 22-29 GHz band and directional antennas must be employed. The center frequency of the emission and the frequency at which the highest radiated emission occurs must be greater than 24.075 GHz. These devices detect the location and movement of objects near a vehicle, enabling features such as near collision avoidance, improved airbag activation, and suspension systems that better respond to road conditions. Attenuation of the emissions below 24 GHz is required above the horizontal plane in order to protect space borne passive sensors operating in the 23.6-24.0 GHz band.[11]

- ***Communications and Measurement Systems*:** This category encompasses a wide variety of other UWB devices, such as high-speed home and business networking devices as well as storage tank measurement devices subject to certain frequency and power limitations. The devices must operate with their -10 dB bandwidth within the frequency band 3.1-10.6 GHz. The equipment must be designed to ensure that operation only can occur indoors, or it must be hand held in which case it may be operated anywhere. Hand held devices may be employed for such activities as peer-to-peer operation.

6. Subsequent to release of the *R&O*, fourteen petitions for reconsideration were filed seeking reconsideration of various aspects of the Part 15 UWB regulations, as described above. A list of the petitioners, along with the abbreviations used to identify them and the parties that filed comments in response to the petitions, is attached as Appendix C.

III. PETITIONS FOR RECONSIDERATION

7. The petitions for reconsideration can be divided into three general categories: those from developers of UWB devices that seek to expand on the UWB standards to permit or facilitate a particular type of operation; those from organizations representing authorized radio services that seek additional attenuation of UWB emissions in the frequency bands used by their devices; and those seeking changes to the Part 15 rules for non-UWB operation. The UWB developers consist of Time Domain, AGA and AGPA, GPRIC, GPR Providers, NUCA, MSSI, Siemens VDO, and Kohler. The organizations representing authorized radio services consist of Cingular, Qualcomm, Sprint, Sirius and XM, SIA, and ARINC and ATA. In addition, MSSI requests that we amend our peak power limits on non-UWB Part 15 devices. We will discuss the petitions under these three groupings in order to facilitate the analyses of the raised issues. The petitions from UWB developers are grouped according to the individual categories of UWB devices that would be affected, *e.g.*, GPRs. The petitions from the representatives of the authorized radio services are grouped according to the radio services they address.

A. Petitions for reconsideration from the UWB equipment developers:

1. Public safety imaging systems

8. The UWB rules require through-wall imaging systems to operate with their -10 dB bandwidth located below 960 MHz or between 1.99-10.6 GHz. Imaging systems may not be used in conjunction with tag identifiers used to locate personnel nor may imaging systems be used to transmit voice or data information.[12] Communications systems are required to operate with their -10 dB

[11] The specific attenuation requirements are described in 47 C.F.R. § 15.515(c).

[12] 47 C.F.R. §§ 15.503(e) and 15.521(f).

bandwidth located between 3.1-10.6 GHz. Through-wall systems are required to attenuate emissions in the GPS band by 10 dB below the Part 15 general emission limits,[13] *i.e.*, to -51.3 dBm/MHz, in the 1610-1990 MHz band and by 12 dB below the Part 15 general emission limits, *i.e.*, to -53.3 dBm/MHz, in the 960-1610 MHz band. Other UWB devices are subject to even greater attenuation of emissions in these bands.

9. Petition. Time Domain requests that the regulations be amended to permit UWB through-wall imaging systems to operate at a lower frequency and at a higher power level than permitted under the rules adopted in the *R&O*. The UWB rules require a through-wall imaging system to operate with its -10 dB bandwidth above 1.99 GHz and below 10.6 GHz.[14] Operation is limited to law enforcement, fire and emergency rescue organizations.[15] Time Domain states that its through-wall imaging system operates at the Part 15 general emission limits with a nominal center frequency of 2.0 GHz and that the emissions from this system are 5 dB below the Part 15 general emission limits at 1610 MHz.[16] Time Domain also states that it is necessary to operate at this frequency and power level in order to obtain, as required by SWAT officers, reliable imaging to 20 feet behind the wall or door through which the UWB transmission is directed.[17] Time Domain also wishes to implement a system that would permit the use of locator tags to track firefighters within buildings and to permit communications with those firefighters, features currently prohibited under the UWB rules for imaging systems.[18] Time Domain notes that none of the interference studies, when examined in light of realistic deployment scenarios, reveal a credible threat of harmful interference to licensed services from its product due to the limited number of UWB systems that would be deployed and operated.[19] It adds that the *R&O* simply relied on NTIA's position for UWB standards. Time Domain notes that its UWB systems primarily are used indoors and that an additional 10 dB of attenuation would be provided for narrowband emissions in the GPS bands.[20]

10. Comments. The USGPSIC opposes Time Domain's requests for the use of locator tags and the use of higher emission levels.[21] It states that such devices are limited to operation above 3.1 GHz due to their propensity, based on the NTIA and RTCA GPS interference studies, to disrupt established radio services in lower frequency bands. USGPSIC also expresses its belief that it is unwise at this early stage to begin carving out exceptions to newly adopted rules that have not yet been put into practice. USGPSIC also states that through-wall imaging systems are known interferers that must be licensed to protect public safety, adding that firefighters rely on GPS. AWS states that the existing limits already are too lenient, that requests to increase those limits must be rejected, and that the emission limits must be tightened to account for aggregate emissions.[22] Time Domain replies that no tests showed harmful

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13 As used in this MO&O, the term "Part 15 general emission limits" refers to the emission limits specified in 47 C.F.R. § 15.209. For emissions above 1000 MHz, this limit is equivalent to an equivalent isotropically radiated power (EIRP) of -41.3 dBm/MHz.

14 47 C.F.R. § 15.511(a).

15 47 C.F.R. § 15.511(b)(1).

16 Time Domain Petition for Reconsideration at pg. 2-3.

17 *Id.* at pg. 6.

18 *Id.* at pg. 1 and 8. 47 C.F.R. §§ 15.503(e) and 15.521(f).

19 Time Domain Petition for Reconsideration at pg. 9.

20 GPS systems are located in the bands 1164-1240 MHz and 1559-1610 MHz. GPS receivers are approximately 10 dB more sensitive to interference from narrowband (continuous wave-like) emissions than from wideband (noise-like) emissions.

21 USGPSIC comments at pg. 5-8.

22 AWS comments at pg. 2.

interference from UWB devices operating at the emission levels it proposes, and argues that USGPSIC mischaracterizes the findings of these tests in asserting that harmful interference would result from UWB operation below 3.1 GHz.[23] It adds that the NTIA tests assumed a flat earth, no buildings, no foliage, prefect alignment of antennas, no multipath, GPS satellites with worst-case multiple access noise (code alignment), all GPS satellites at their end-of-life power output, perfect availability and performance of GPS signals regardless of GPS receiver location, and the use of a UWB CW signal phase locked to a sensitive GPS spectral line so that the signals were continually tracked – a condition that would never arise – in order to show that a 34 dB reduction below the Part 15 general emission limits was required. Time Domain believes that realistic assumptions would have shown that the general emission limits were sufficient to prevent harmful interference. We also note that a large number of public safety organizations endorsed the Time Domain system in response to the *Notice of Proposed Rule Making* ("*Notice*")[24] in this proceeding.

11. Discussion. We agree with the request from Time Domain to permit through-wall imaging systems to operate at a lower frequency and a subsequently higher emission level. We believe that the potential for using UWB devices to save the lives of firefighters, emergency rescue personnel and law enforcement officers and to assist those parties in saving the lives of the public clearly outweighs the relatively low risk that these devices, even operating under the worst possible scenarios, may cause interference to GPS receivers located a few meters away. We concur that the imaging system envisioned by Time Domain should be allowed to be implemented under our regulations. We also believe that any potential increase in harmful interference would be minimal, occurring only within a few meters of the UWB device. In addition, we believe that the petition from Time Domain is unique from the other petitions filed in this proceeding. The Time Domain system would be employed only in limited quantities, under safety-of-life circumstances, and at emission limits that are unlikely to cause harmful interference. Further, due to the extremely close range at which interference could occur it is highly likely that any radio systems receiving interference would be under the direct control of the licensed public safety personnel operating the UWB equipment. This would permit the UWB operator to determine, based on the conditions unique to each emergency situation, the specific radio equipment that is most viable to protect the lives of both the public and the emergency personnel involved and to manage the operation of that equipment. As these same public safety operators also employ GPS and other communications systems, they will be aware of any possible interactions between these systems and are in the best position to determine if the UWB system should be employed. While we are continuing to follow a conservative approach in the implementation of standards for UWB operations, we believe that the safety-of-life applications of this UWB equipment, combined with the limitation that operation must be by licensed public safety radio operators who can temper any possible adverse equipment interactions, justify the adoption of Time Domain's proposal.

12. The emission limits established for UWB operation in the 960-1610 MHz band were based on conservative models requested by NTIA, the Department of Defense, the US GPS Industry Council and others. These models were based on a 1 dB increase in the noise floor of the GPS receiver with the GPS receiver and the UWB device separated by conservative distances. Further, these models were established for UWB devices that could be employed in large quantities by the general public or could be employed as imaging systems by a smaller but unknown number of users. However, the Time Domain through-wall imaging devices are envisioned for use in law enforcement and emergency service operations following a natural or man-made disaster, *e.g.*, an earthquake, fire, or an act of terrorism. Under these circumstances, access to the site by the general public will be severely restricted. Thus, the short separation distances assumed in developing the general UWB emission limits for this band are not appropriate for this UWB application. Furthermore, as indicated the public safety operators of this

[23] Time Domain reply comments at pg. 2-4.

[24] *Notice of Proposed Rule Making* in ET Docket No. 98-153, 15 FCC Rcd 12086 (2000).

equipment will be able to determine what equipment should be operated and to control the proximity of those devices. Accordingly, we see no need to provide stringent UWB emission limits to protect other nearby radio operations such as indoor enhanced GPS reception.

13. We are not proposing at this time to reevaluate the UWB emission limits in the GPS and other frequency bands for existing UWB devices. However, we recognize that the safety-of-life applications provided by the Time Domain system should be considered in a different light, especially since that equipment would be used only by a smaller number of licensed public safety officials under limited operational circumstances and that these public safety officials will be able to determine what, if any, impact the operation of the UWB equipment will have on other nearby radio operations. Accordingly, we have taken another look at the analysis of the interference potential from the Time Domain UWB system to GPS reception. In this new analysis, we note that Time Domain indicated that the emissions from its transmission would be attenuated by 5 dB below the Part 15 general emission limits at frequencies below 1610 MHz. Since the fundamental emission of the Time Domain device would be permitted at an EIRP of -41.3 dBm/MHz, this results in emissions in the GPS band being no greater than -46.3 dBm/MHz. Under these circumstances, the following link budget applies:

Parameters	Levels
GPS receiver susceptibility (dBm/MHz)	-117.5 [25]
GPS antenna gain (dBi)	0
UWB emission limit in EIRP (dBm/MHz)	-46.3 [26]
Required path loss (dB)	71.2
Maximum separation distance (m)	55

14. While the above link budget specifies a maximum separation distance between the UWB through-wall imaging system and a GPS receiver, we recognize that actual interference distances will be considerably shorter. First, the UWB emission limit is based on a level that could result in a 1 dB increase in the noise floor of a GPS receiver under very conservative conditions. To our knowledge, no correlation has ever been made between this slight rise in the noise floor and actual GPS harmful interference. Indeed, tests performed by NTIA, DOT and Time Domain all demonstrate that GPS receivers are capable of rejecting higher UWB emission levels even when the GPS received signals are at minimal levels and the emissions from the UWB devices are adjusted to produce a maximum impact on the GPS receiver. Second, the calculated maximum separation distance is based on worst case conditions, *e.g.*, no intervening objects, the maximum emission from the UWB device directed towards the GPS receiver, and perfect antenna alignment between the UWB device and the GPS receiver. Third, the fundamental emission of the through-wall imaging system always would be directed at the wall of a building and that building would provide an additional 9 dB of attenuation, on the average, at the GPS frequency.[27] Fourth, we note that Time Domain's current equipment design employs the use of a directional antenna which will ensure that the maximum emission levels are directed at the building and will minimize emissions in other directions. Based on the low probability that all worst case conditions would apply at the same time, it is likely that considerably shorter separation distances would apply in actual practice. Accordingly, while the above link budget analysis demonstrates that operation of Time

[25] This is the value that was recommended by NTIA and USGPSIC and was used in the *R&O*. It represents a level that is 6 dB below the thermal noise floor of the GPS receiver and that would result in a 1 dB increase to the noise floor of the GPS receiver.

[26] This is the Part 15 general emission limit, -41.3 dBm/MHz, combined with the 5 dB of attenuation that Time Domain indicated could be applied below 1610 MHz.

[27] NTIA Special Publication 01-47, *Assessment of Compatibility between Ultrawideband (UWB) Systems and Global Positioning System (GPS) Receivers*, at pg. 3-7.

Domain's proposed through-wall imaging system could result in increased noise to GPS receivers, this would occur only to those receivers in the immediate vicinity of the UWB transmitter, *i.e.*, to those receivers that are under the control and supervision of the same public safety agencies operating the UWB through-wall imaging equipment.

15. We agree that any technology that increases the survivability of our police, emergency rescue personnel and firefighters should be encouraged. As a result of the factors discussed in the preceding paragraphs, we are amending our rules to permit the operation of a through-wall imaging system with a center frequency above 1990 MHz at the Part 15 general emission limits. However, we acknowledge the concerns expressed by the commenters and believe that some additional operational standards should be implemented to ensure that operation of this equipment does not result in harmful interference to other radio systems that may also be employed for public safety purposes. We do not believe that any of these standards will cause operational difficulties. First, we are limiting the proliferation of such products by authorizing the use of this equipment only by law enforcement officers, emergency rescue personnel and firefighters operating under the authority of a local or state government. Second, we are requiring that the operators of such systems be licensed by the Commission under Part 90 of our regulations. Part 90 permits the operation of public safety radio communications systems. The grant of a Part 90 license for operation of a land mobile station will automatically convey authority to operate this through-wall imaging system. The license may be held by the organization under which the UWB operator is employed. This is similar to the current provisions that permit law enforcement agencies to operate vehicle speed radar systems under the provision that they hold a valid land mobile radio license.[28] However, unlike the licensing of Part 90 radars, by retaining these provisions under Part 15 we are requiring that the UWB devices continue to operate on a sufferance basis without interference protection. Third, we are requiring that this equipment be operated only for law enforcement applications, the providing of emergency services, and necessary training operations. Because of the possibility that some training areas may be located near public access areas where receiving equipment may not be under the immediate control of the UWB device public safety operator, at the request of NTIA we are requesting that during training exercises through-wall imaging systems operating above 1990 MHz be encompassed by a 50 meter perimeter within which public access is restricted. Finally, we are requiring that the UWB public safety communication system transmitter operate with its center frequency, as defined in 47 C.F.R. § 15.503(b), between 1990 MHz and 10.6 GHz. The frequency at which the highest radiated emission occurs must be located in the 1.99 GHz to 10.6 GHz band and must not exceed an average root-mean-square (RMS) EIRP of -41.3 dBm/MHz. In addition, broadband emissions between 960 MHz and 1610 MHz must not exceed an average (RMS) EIRP of -46.3 dBm/MHz, when measured using a resolution bandwidth of at least 1 MHz, and narrowband emissions in the GPS bands must be attenuated so that they do not exceed an RMS EIRP of -56.3 dBm, when measured using a resolution bandwidth of no less than 1 kHz. We also are requiring that the emissions appearing below 960 MHz not exceed the Part 15 general emission limits and that any emissions above 10.6 GHz not exceed an RMS EIRP of -51.3 dBm/MHz.

16. Due to the nature of the scenarios in which these through-wall imaging systems will be employed, *e.g.*, law enforcement and emergency services operations, we believe that coordination of these devices prior to operation is neither reasonable nor necessary. For similar reasons, we are relinquishing the requirement that these devices be equipped with a manual transmission switch. Finally, we note that the new public safety imaging system incorporates provisions that permit the use of through-wall imaging systems at emission levels more lenient than those that were adopted under the *R&O*. Accordingly, we are eliminating the separate provisions for mid-frequency through-wall imaging systems in 47 C.F.R. § 15.511 as it is redundant with the new provisions for public safety imaging systems. The specific regulations being adopted to permit this expanded UWB application are shown in Appendix B.

[28] 47 C.F.R. § 90.20(f)(4).

17. At this time, we are not adopting changes to the rules to implement the tracking or communication system suggested by Time Domain. In its petition, Time Domain indicated its desire to implement such a system but provided only general statements indicating that it should operate under the same emission standards as applied to through-wall imaging systems. We do not believe that sufficient information has been received to determine what standards are necessary to implement a tracking and communications system for public safety applications. Further, there is no indication at this time that such a device could not operate successfully under the UWB provisions already adopted. Once a public safety tracking and communications system has been sufficiently developed to permit us to consider its required operating parameters and subsequent interference potential, additional changes to the UWB rules could be addressed.

2. Ground penetrating radar systems

18. As noted above, the rules adopted in the *R&O* required GPRs and wall imaging systems[29] to be operated by law enforcement, fire and emergency rescue organizations, by scientific research institutes, by commercial mining companies or by construction companies. The operation of these devices is subject to the requirement that the operator coordinate the operational location with the Commission. A dead man switch is required to ensure that the UWB device ceases to operate within 10 seconds of being released by the operator. These products must operate with their -10 dB bandwidth below 960 MHz or between 3.1-10.6 GHz and may operate within those bands at the Part 15 general emission limits. Emissions within the 960-3100 MHz band are required to be attenuated below the Part 15 general emission limits by 10 to 24 dB, depending on the frequency. In an earlier *Order*,[30] the Commission relaxed the operational restrictions for GPRs and wall imaging systems, permitting this equipment to be used for the purposes prescribed in the rules, and relaxed the coordination requirements, permitting GPR and wall imaging system operators to submit a single filing encompassing operation over a wide geographical area.

19. Petitions. AGA and APGA, GPRIC, GPR Providers and NUCA filed petitions for reconsideration requesting that the Commission relax the restrictions on who may operate GPRs.[31] In general, the petitioners note that existing GPRs are not operated by the parties identified in the regulations but are operated by independent small businesses for a myriad of public safety applications.[32] The GPRIC does not object to requiring GPR users to be limited to parties eligible to operate under Part 90.[33] Similar thoughts were expressed by the GPR Providers who request that we establish a new operating category entitled "Subsurface testing eligible," defined as a commercial enterprise that provides professional subsurface testing services to others on a contract basis.[34] GPRIC and the GPR Providers also request that the requirements to coordinate the operation of GPRs be eliminated.[35] GPRIC is concerned that coordination would be required before every GPR operation and that these operations will be unnecessarily delayed waiting for the coordination to be completed. It does not object to a rule that identifies specific installations and requires coordination of GPRs operated within a reasonable radius of

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[29] A wall imaging system is essentially identical to a GPR except that it is used to detect the location of objects within a wall or determine the properties of a wall rather than of the ground.

[30] *See Order* ("*Order*") in ET Docket No. 98-153, 17 FCC Rcd 13522 (2002). This *Order* was issued under the delegated authority of the Chief of the Office of Engineering and Technology.

[31] Petition for Reconsideration of AGA and APGA at pg. 5; Petition for Partial Reconsideration of GPRIC at pg. 8-16, Petition for Partial Reconsideration of GPR Providers at pg. 8-10, and letter from NUCA at pg. 3.

[32] *See*, for example, the Petition for Partial Reconsideration of GPR Providers at pg. 2-7.

[33] Petition for Partial Reconsideration of GPRIC at pg. 15.

[34] Petition for Partial Reconsideration of GPR Providers at pg. 8-10.

[35] Petitions for Partial Reconsideration of GPRIC at pg. 8-16 and GPR Providers at pg. 10-14.

those installations. GPR Providers also requests that coordination be required only for sites where it truly is warranted, permitting the GPR user to register with the Commission and operate anywhere outside of these specified areas without further coordination. GPRIC believes that both of these provisions were adopted unlawfully as they were not specifically proposed for public comment, have no support in the comments filed in the record for this proceeding, and omit a large majority of the current users, with the effect that these restrictions would eliminate many of the public interest benefits currently derived from GPRs.

20. GPR Providers requests that the regulation requiring a dead man switch on the equipment be replaced with a requirement that operation occur only under the control of an eligible operator.[36] It notes that no purpose would be served by leaving the equipment transmitting without operator direction and control and notes the difficulties of attempting to operate a GPR, observing data and marking reference locations, all while looking where they are going. GPR Providers notes that a requirement to hold down a switch to operate a GPR would result in having to use a second operator simply to operate this switch or risk having to repeat an entire site investigation should the switch accidentally be released during the survey.

21. Both GPRIC and GPR Providers request that GPRs be permitted to operate at the Part 15 general emission limits and within the frequency band between 960 and 2000 MHz.[37] GPRIC and GPR Providers state that there is no evidence in the record suggesting that GPRs present any threat of interference and there is no technical justification for requiring the low emission levels adopted in the *R&O*. GPRIC notes that a product can be shown to comply with the requirement to contain the -10 dB bandwidth below 960 MHz simply by adding noise to the emissions below 960 MHz, thereby increasing the potential interference to radio services below 960 MHz, even though the transmitter actually would be operating above 960 MHz. GPR Providers notes the necessity to operate GPRs in the 1-2 GHz region in order to obtain adequate image resolution. GPR Providers also notes that more numerous unintentional radiators already are permitted to operate at the general emission levels.

22. GPRIC believes that the requirement in the rules to measure peak emissions from low frequency imaging systems should be deleted.[38] It states that the existing requirement to employ quasi-peak emission measurements below 960 MHz is sufficient to regulate interference potential and notes the Commission's earlier statement in the *R&O* that quasi-peak emissions will closely approximate the peak levels produced by imaging systems operating below 1000 MHz.[39]

23. GPR Providers requests that we reconsider our certification in the *R&O* that there will be no significant economic impact on a substantial number of small business and to conduct the regulatory flexibility analysis on the new rules as required under 5 U.S.C. 601 *et seq*.[40] It argues that the effects of the new rules on the GPR industry were not adequately considered.

24. Comments. The USGPSIC opposes all of the regulatory changes sought by the GPR community, requesting that the status quo be maintained.[41] It believes that expanding the list of eligible GPR operators would increase the permitted number of GPR systems and that this would result in an

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[36] GPR Providers Petition for Partial Reconsideration at pg. 14-16. A dead man switch is a switch that causes the unit to cease operation if it is released.

[37] Petitions for Partial Reconsideration of GPRIC at pg. 16-19 and GPR Providers at pg. 16-19.

[38] GPRIC Petition for Partial Reconsideration at pg. 19-20. *See* 47 C.F.R. § 15.509(f).

[39] *R&O*, *supra*, at footnote 325.

[40] GPR Providers Petition for Partial Reconsideration at pg. 19-20.

[41] USGPSIC comments at pg. 9-17.

unacceptable risk of interference to GPS and would increase the number of coordination requests and the administrative burden.[42] AWS also objects to expanding the list of authorized users and requests that existing broad user categories, such as "industrial entities" for surveillance systems, be removed.[43] GPR Providers responds that the list of eligible users should be expanded to incorporate the relaxation to the category of users the Commission specified in its recent *Order* in this proceeding.[44] It indicates that no dramatic expansion of users is expected as the GPR and wall imaging industry has a slow growth rate, equipment is expensive, and it appears that we intended to authorize this expanded category of users anyway. It adds that USGPSIC offers no evidence that such a change would further expand the number of users. GPRIC reiterates that the limit on who may operate GPRs was adopted without notice or comment and without any support in the record, omitting federal, state and local transportation departments along with the professional firms that provide them with GPRs.[45] In response to USGPSIC's claims of increased interference to GPS due to increased proliferation, GPRIC notes that GPRs do not cause interference with GPS and that emissions from GPRs cannot aggregate as there never would be a demand to simultaneously operate a significant number of GPRs in close proximity as this would degrade the performance of the GPRs. GPR Providers repeats that GPRs have been operated for over 30 years with no reports of interference.[46]

25. USGPSIC states that the coordination requirement is not a burden and is a logical outgrowth of our rulemaking proposal since coordination was required for UWB products previously authorized under a waiver and because one commenting party requested that UWB systems operating above the general limits be coordinated.[47] USGPSIC wishes to retain the existing rules believing that the request from GPR Providers to permit GPR operators to register with the Commission, specifying an intended area of operation, is unduly complex and does not address the "real time" concerns of safety services such as GPS. GPRIC again claims that the coordination requirements were adopted without notice or comment.[48] It states its belief that the *Notice* did not alert the public that a rule requiring coordination was under consideration and therefore did not meet the Administrative Procedure Act ("APA") requirements.[49] GPR Providers notes that the Commission's recent *Order* addressing GPR operation took a significant step towards ameliorating the problem.[50] It adds that there is nothing complex about a GPR equipment registration system and again suggests that the Commission make available to the public a list of sites about which NTIA has concerns and limit pre-coordination to those areas.

26. USGPSIC opposes eliminating the dead man switch stating that this switch eliminates the element of human error and that the burdens associated with this switch do not outweigh the need to

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42 USGPSIC comments at pg. 14.

43 AWS comments at pg. 15.

44 GPR Providers reply comments at pg. 5. The provisions of this *Order* are examined in our discussion of the GPR petitions.

45 GPRIC reply comments at pg. 4-5.

46 GPR Providers reply comments at pg. 3.

47 USGPSIC comments at pg. 12. The previous UWB waivers, issued to Time Domain Corporation and to U.S. Radar Inc. on June 25, 1999, required coordination. The comment referenced by USGPSIC was a comment filed by Zircon in response to the *Notice of Inquiry* ("*NOI*") in ET Docket No. 98-153, 13 FCC Rcd 16376 (1998) at para. 17, stating that GPRs should be permitted to operate at the limits applicable to Class A digital devices provided these devices are coordinated with NTIA and registered in a data base.

48 GPRIC reply comments at pg. 3-4.

49 *See* 5 U.S.C. 553.

50 GPR Providers reply comments at pg. 6.

protect public safety services from stray GPR transmissions.[51] In response, GPR Providers repeats its earlier claim that the inclusion of a dead man switch could compromise the operator's attention to details of the survey, many of which are performed in construction sites or other potentially hazardous environments.[52]

27. USGPSIC also opposes allowing the operation of GPRs between 960 MHz and 3100 MHz, stating that this would open the door to additional small commercial users, since the vast majority of GPR applications require operation above 960 MHz.[53] It indicates that permitting operation in this band would contradict the Commission's policy of protecting public safety services, adding that co-frequency GPR and GPS operation is not feasible.[54] Finally, USGPSIC argues that the emission limits established in the *R&O* must not be relaxed, stating that we must not revise the levels previously adopted in the absence of testing which supports increased emission limits.[55] It believes that interference caused by an unintentional radiator, such as a computer, is not a concern since the emission levels radiated by such devices can be reduced without affecting the functioning of that device, whereas lowering the emissions produced by a GPR would disrupt the functioning of that device. GPR Providers disagrees with USGPSIC that higher limits are acceptable only for unintentional radiators, noting that there are millions of personal computers versus a few hundred GPRs.[56] It adds that no harmful interference was predicted from GPRs under any test approximating real world conditions. GPR Providers further notes that many GPRs incorporate a GPS receiver as an integral part of the operation without experiencing any interference problems. GPRIC believes that lower limits for GPRs were adopted contrary to all relevant evidence in the record and that long experience shows that GPRs operating at or near the Part 15 general emission limits have no effect on GPS operation.[57] It disputes the USGPSIC comment regarding lack of testing evidence citing daily operation of GPRs with directly attached GPS receivers without interference problems. GPRIC adds that the existing rules arbitrarily eliminate the operation of GPRs above 960 MHz no matter how low the emission levels are and that this adds no protection to GPS but hinders GPR applications.

28. Discussion. As noted by GPR Providers, an *Order* recently was issued addressing the categories of entities permitted to operate GPRs and wall imaging systems.[58] In that *Order*, it was noted that the regulations require that GPRs and wall imaging systems be used only by law enforcement, fire and emergency rescue organizations, by scientific research institutes, by commercial mining companies, and by construction companies. Since the adoption of the *R&O*, we have received several inquiries from the operators of GPRs and wall imaging systems noting that these devices often are not operated by the parties listed in the regulations but are operated instead under contract by personnel specifically trained in the operation of these devices. We continue to believe that the recent adoption of the UWB rules should not result in disruption of the critical safety services that can be performed effectively only through the use of GPRs and wall imaging systems. We also find it acceptable that GPRs and wall imaging systems are used for one of the purposes described in the regulations without being physically controlled by one of the described parties. For example, a subcontractor may operate GPRs and wall imaging systems to inspect buildings, roadways, and bridges to determine if construction or repair is required. As a second

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51 USGPSIC comments at pg. 15-16.

52 GPR Providers reply comments at pg. 6-7.

53 USGPSIC comments at pg. 15.

54 *Id.* at pg. 17.

55 *Id.* at pg. 9-10.

56 GPR Providers reply comments at pg. 7-8.

57 GPRIC reply comments at pg. 5-6.

58 *See Order*, *supra*, at para. 9-10.

example, a GPR may be operated by a private company investigating forensic evidence for a local police department. We believe that this viewpoint will satisfy the concerns of the petitioners, and we are amending the rules to reflect this interpretation. Following this interpretation of the eligibility requirements, there no longer is any need to require GPRs and wall imaging systems to carry a label designating who may operate the equipment. We do not agree with USGPSIC that this liberalization of the categories of operators will significantly increase the proliferation of GPRs and wall imaging systems nor do we believe that this will result in increased interference to GPS reception. We concur with GPR Providers that no dynamic expansion in the use of GPRs and wall imaging systems should result from this modification of the usage restrictions. Our interpretation of the eligibility requirements should not increase the usage of these devices beyond the levels at which experience has already demonstrated a lack of interference problems. As pointed out by the GPRIC and the GPR Providers, these devices have been used for many years with attached GPS receivers without a single incidence of reported harmful interference.

29. This modification of the operating restrictions will not extend to UWB imaging systems other than GPRs and wall imaging systems. We are not aware of any existing UWB surveillance, medical imaging, or through-wall imaging systems for which the current rules would have an adverse impact. These systems are relatively new products, and we therefore believe that their operation should be limited until more experience has been obtained.

30. The recent *Order* in this proceeding also simplified the coordination procedure applicable to GPRs and to wall imaging systems.[59] In particular, it clarified that the individual reporting and coordination of each operation of an imaging system is not required. Rather, the coordination report associated with a GPR or with a wall imaging system may simply list the geographical area(s), *i.e.*, the state(s) or county(ies) in which the equipment will be operated. Upon receipt by the Commission, the coordination information is forwarded to NTIA. NTIA will identify the geographical areas within which the operation of an imaging system requires additional coordination or within which the operation of an imaging system is prohibited. If additional coordination is required for operation within specific geographical areas, a local coordination contact will be provided. This coordination may be conducted by telephone with the local contact; a separate report to the Commission for each operation of the imaging system is not required. Except for operation within these designated areas, once the information requested on the UWB imaging system is submitted to the Commission, no additional coordination with the Commission is required, provided the reported areas of operation do not change or the equipment is not sold to a different operator. If the area of operation changes or the equipment is sold, updated information must be submitted to the Commission.

31. The coordination procedures apply to all imaging systems. Mobile devices, such as wall imaging systems and through-wall imaging systems, by their nature, could be used over a wide range of geographical locations. A company using these products likely will operate them over several counties, or even over several states or country-wide and it is required that these geographical areas be reported in the filing of coordination information with the Commission. However, fixed devices, such as surveillance systems and medical imaging systems, are only operated at one location. Accordingly, we will require the operator of a fixed imaging system to provide the specific geographical location or address of the transmitter.

32. While it may be arguable whether these provisions could have been anticipated from the general outlines of the proposals we raised and that were debated in the rulemaking, these requirements were demanded by NTIA as a condition to permit operation in radio spectrum allocated for U.S. Government operations. The alternative to these provisions would have been to require that each operation of GPRs and wall imaging systems be individually coordinated and authorized under the

[59] *See Order*, *supra*, at para. 6.

experimental provisions in Part 5 of our rules. In any event, interested parties have now had the opportunity to consider and comment on these issues and have done so thoroughly. We have the full benefit of their arguments in reaching our decision here. We believe that the changes adopted in the recent *Order* permitting a one-time submission to the Commission of a description of the intended areas of operation will satisfy the concerns of the petitioners.

33. We concur with the comments from the GPR Providers that the inclusion of a dead man switch on some GPRs could result in operating difficulties and, depending on where the equipment is used, could raise safety concerns for the operator. We believe that the concerns expressed by the GPR Providers are directed primarily to larger GPRs, such as those that would be towed behind, or attached to, a vehicle and used to investigate the integrity of highways or bridges. It is likely that these larger GPRs would be operated only when they are pointed at the ground, ensuring that the emissions from the antenna are absorbed and attenuated. On the other hand, NTIA has expressed its concern to us that small imaging systems, designed to be operated while hand held, could be placed in a position, such as on their side, where the antennas are not pointed at the ground or at other attenuating objects. Without the incorporation of a dead man switch, these devices could be left in the transmitting mode inadvertently and the unattenuated emissions from the antennas could cause harmful interference. Accordingly, we are amending the regulations to remove the dead man switch requirement for GPRs that are not designed to be used as hand held devices. At the request of NTIA, we are retaining our requirement that GPRs that are designed to be operated as hand held devices and all wall imaging systems incorporate a dead man switch. We do not believe that the requirement to include a dead man switch on these latter devices presents operating difficulties or raise safety concerns. As no similar concerns were addressed regarding the inclusion of a dead man switch for other imaging systems, we are retaining that requirement until more experience has been gained with those devices. We also are revising the language in the regulations regarding remote operation to clarify that this can be used in lieu of the dead man switch.

34. With regard to permitting the operation of GPRs in the 960-3100 MHz band at the Part 15 general emission limits, we concur with the comments that there have been no cases of reported interference from the operation of GPRs.[60] Further, we disagree with USGPSIC that no testing has occurred. There has been extensive testing in this proceeding by NTIA, by DOT/Stanford, and by Time Domain/University of Texas/Johns Hopkins of potential interference to GPS reception. Those studies found that no interference was caused to a GPS receiver when the pulse repetition frequency ("PRF") was operated at no greater than 100 kHz.[61] While NTIA performed its tests employing a 100 kHz PRF, we also observe that operation of a GPR with a bandwidth 10 percent or less of the GPS receiver bandwidth, *i.e.*, 200 kHz, should not result in any significant difference in the interference effect to GPS receivers.[62] These are typical PRFs employed today in GPRs, many of which have GPS receivers mounted inches

[60] While the Commission has been informed unofficially, *i.e.*, no report was ever placed in the record for this proceeding, of one possible case where the operation of GPR with an emission centered around 500 MHz caused the noise level in a VHF aviation receiver at an airport to increase, it is our understanding that this noise was seen when the GPR found a broken antenna cable under the tarmac of the airport. This is not an indication of harmful interference but is an example of how a GPR can successfully be employed to find problem areas in an airport runway tarmac.

[61] *R&O*, *supra*, at para. 78. NTIA informs us that the measurements performed by DOT considered a single UWB signal and that the NTIA measurements indicated that the aggregate signal tends to "fill in" the off periods as the number of 100 kHz PRF signals increase, resulting in an interference effect that is noise-like. However, we observe that it is extremely unlikely that multiple GPRs would be operated simultaneously in close proximity to each other. Accordingly, this effect would not occur from the operation of GPRs.

[62] This observation on PRF is applicable only for UWB signals that are generated by an impulse or pulsed modulation.

away from the antenna without any adverse interference effects.[63] Accordingly, we do not agree with USGPSIC that the operation of GPRs, particularly those operating with PRFs below 200 kHz, would cause harmful interference to GPS reception.

35. It has been our observation that GPRs are specialized devices and are few in number. Given the nature of their use, the quantities involved, and the low limits applicable to emissions from these devices, there is little chance that GPRs will cause harmful interference. We concur with the petitioners that there is a need for GPRs to operate at frequencies between 960 MHz and 3100 MHz in order for them to perform their required functions. For these reasons, we are amending our rules to permit GPRs to operate at any frequency below 10.6 GHz as long as the emissions comply with the applicable limits. We are including wall imaging systems under the same provisions as those applied to GPRs as there is essentially no technical differences between these products. However, at the request of NTIA and based on our desire to proceed with an abundance of caution we are not changing the emission limits applicable to GPRs at this time.

36. We agree with GPRIC that the requirement to demonstrate compliance with a peak emission limit for imaging systems operating below 960 MHz should be specifically deleted from our rules. As indicated in the *R&O*, the requirement to measure emissions using a quasi-peak detector is sufficient without the need for a separate peak limit.[64] Removing the peak measurement also is consistent with other Part 15 regulations which require separate peak measurements only when the standards are based on the use of an average detector.[65] Accordingly, we are amending the rules to specify that the measurement of a peak emission level is not required for low frequency imaging systems.

37. Finally, in the *R&O* the Commission, in reference to the Final Regulatory Flexibility Certification, certified that the adoption of the UWB rules would not have a significant economic impact on a substantial number of small entities.[66] We disagree with GPR Providers that this certification is incorrect. Prior to adoption of the *R&O*, the only legally sold and operated GPRs within the U.S. were a few units operating under experimental licenses issued by the Commission and the GPRs manufactured by U.S. Radar under a waiver.[67] All other GPRs were sold and operated without appropriate legal authority,[68] and normally would not be considered under an economic impact statement. However, we recognized the public safety benefits from incumbent GPR operations and the lack of harmful interference problems from these devices. Rather than instigating enforcement actions against the manufacturers and incumbent users and halting all existing GPR operations, the Commission accommodated legacy GPRs, *i.e.*, GPRs that were purchased prior to July 15, 2002, under a blanket waiver granted in the recent *Order*. Accordingly, the adoption of the UWB regulations did not have a significant impact on the small entities involved in the legal manufacture or marketing of GPRs, nor did it have an impact on the small entities operating existing GPRs within the U.S.

3. Wideband radar and other low PRF systems in the 3.1-10.6 GHz band

38. UWB consumer devices are required to operate with their -10 dB bandwidth in the

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[63] NTIA believes that in all instances where compatibility is cited between GPS receivers attached to the GPR that the PRF of the GPR has been less than 100 kHz.

[64] *R&O*, *supra*, at para. 323.

[65] 47 C.F.R. § 15.35(b).

[66] *R&O*, *supra*, at para. 277.

[67] NTIA also issued authorizations permitting a GPRs to be operated by a few Federal Government agencies, *e.g.*, by the U.S. Department of Justice.

[68] 47 U.S.C. § 302; 47 C.F.R. §§ 2.803, 15.1.

3.1-10.6 GHz band and are limited to indoor-only and hand held systems. These systems must comply with the UWB definition by operating with a minimum fractional bandwidth[69] of 0.20 or with a minimum -10 dB bandwidth of 500 MHz. In the *R&O*, the Commission agreed with earlier comments from XSI, Bosch, ARRL and Delphi that wideband transmission systems should not be precluded because they achieve the wide bandwidth due to a high speed data rate or because they use a particular type of modulation.[70] Rather, it concluded that the emission limits on peak, average and power spectral density are sufficient to control interference potential.

39. Petition. MSSI requests that any type of UWB device, *e.g.*, a vehicle radar system, be permitted to operate in the 3.1-10.6 GHz band provided it employs a low PRF. It states that the restriction of UWB vehicular radar systems to operate in the 22-29 GHz band was arbitrary, capricious and without basis.[71] It further argues that the use of a lower PRF reduces the average power levels and the probability that interference would be caused. MSSI adds that the submissions from NTIA, Stanford/DOT and others demonstrated that low PRF systems, particularly those with PRFs below 100 kHz, were benign to GPS receivers.

40. MSSI further requests that we prohibit devices from operating under the UWB regulations if they achieve their wide bandwidth due to high data rates, *i.e.*, where the bandwidth is modulation dependent.[72] MSSI indicates that no test results were submitted in the proceeding for other than pulsed emissions where the bandwidth was determined by the narrow pulse width. MSSI specifically requests that we prohibit the use of bi-phase modulated, high data rate systems that use direct sequence techniques.[73] Finally, MSSI requests that we clarify that the emission charts that accompanied the February 14, 2002, News Release announcing the adoption of the UWB regulations do not correctly reflect the emission limits below 960 MHz.[74] MSSI indicates that the News Release specified an EIRP limit of -41.3 dBm below 960 MHz, but that this is inconsistent with the adopted regulations which stated that the Part 15 general emission limits applied to emissions below 960 MHz. In its comments, MSSI continues that it is the high peak to average ratios that make low PRF UWB systems non-interfering.[75]

41. Comments. SARA, Delphi and XSI object to MSSI's request to exclude devices that achieve their wide bandwidths due to high data rates.[76] SARA notes that MSSI provided no explanation, theoretical calculations or evidence that non-pulsed modulation devices are more likely to cause harmful interference. Delphi adds that MSSI is wrong in its claim that there is no support in the record for the inclusion of non-pulsed systems, and that MSSI could have done its own study. XSI argues that its bi-phase modulation is more power efficient and less interfering than other methods, such as on/off keying and pulse position modulation.[77] It adds that the statements from MSSI regarding decreased interference with lower PRF are a significant distortion of the NTIA interference analysis, where the record clearly shows that systems with a high PRF cause less interference. AWS supports clarification that the emission limits below 960 MHz were subject to the Part 15 general emission limits and not the

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69 The factional bandwidth is the UWB bandwidth, *i.e.*, the -10 dB bandwidth, divided by the center frequency. *See* 47 C.F.R. § 15.503(c).

70 *R&O*, *supra*, at para. 32.

71 MSSI Petition for Reconsideration at pg. 10-11.

72 *Id.* at pg. 12-13.

73 This is the type of modulation employed by the XSI equipment.

74 *Id.* at pg. 15-16.

75 MSSI comments at pg. 4.

76 SARA comments at pg. 2-4; Delphi comments at pg. 1-5; XSI comments at pg. 29-30.

77 XSI reply comments at pg. ix-xi, Technical Statement.

limits represented in the News Release.[78]

42. Discussion. With regard to MSSI's request to permit any type of UWB device employing a low PRF, *e.g.*, a vehicle radar system, to operate in the 3.1-10.6 GHz, MSSI does not consider that the NTIA analysis for systems other than GPS demonstrated that the interference potential from a UWB transmitter may increase when lower PRFs are employed.[79] As noted in our discussion of GPRs, it appears true that GPS receivers are not sensitive to interference from UWB devices operating with PRFs below about 200 kHz. However, this immunity to low PRF interference does not necessarily apply to other radio systems using different receiver designs and modulation types. MSSI has not provided any measurement or other data to demonstrate that additional high-proliferation systems could be added in the 3.1-10.6 GHz without increased interference risks. Accordingly, MSSI's request that we permit any type of UWB device employing a low PRF to operate in the 3.1-10.6 GHz band is denied.

43. With regard to MSSI's request that we prohibit devices from operating under the UWB regulations if they achieve their wide bandwidth due to high data rates, *i.e.*, where the bandwidth is modulation dependent, MSSI has provided no data or other information to support this request. We find no evidence from the petitioner on which to base a change to our earlier decision. Accordingly, this request is denied.

44. Finally, MSSI is correct that the spectrum charts that were included in the press package along with the News Release of February 14, 2002, announcing the adoption of the *R&O* unintentionally did not reflect the emission limits below 960 MHz. The UWB emission limits below 960 MHz are the Part 15 general emission limits contained in 47 C.F.R. § 15.209, as correctly stated in 47 C.F.R. §§ 15.509(d), 15.511(d), 15.513(d), 15.515(d), 15.517(c), and 15.519(c).[80] Accordingly, no change to our regulations is required to implement this clarification.

4. Vehicular radar systems in the 22-29 GHz band

45. The UWB regulations permit the operation of vehicular radar systems in the 22-29 GHz band. UWB vehicular radar systems are required to operate at all times with a minimum 500 MHz bandwidth and may employ any modulation technique that results in this minimum bandwidth. In the *R&O*, the Commission specifically precluded the operation of swept frequency systems and frequency hopping systems under the UWB rules unless the transmissions comply with the minimum bandwidth requirement when measured with the sweep or hopping sequence stopped.[81] The Commission indicated that this was necessary as no measurement procedure had been established to permit the emission levels from such devices to be determined while sweeping or hopping. The Commission expressed similar concerns in the *Notice*, and declined to include transmitters employing swept frequency and similar

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[78] AWS comments at pg. 3.

[79] *See*, for example, *Order*, *supra*, at para. 124 and 131.

[80] We also note that a direct comparison of the emission limits below 960 MHz with those above 960 MHz is not feasible due to the change in the detector functions. Emissions below 960 MHz are measured using a CISPR quasi-peak detector whereas emissions above 960 MHz are measured using an RMS detector.

[81] In the *R&O*, the Commission concluded that it was necessary to establish a minimum UWB bandwidth to prevent narrowband Part 15 devices from operating under the UWB standards, as such operation would allow them to transmit in the restricted frequency bands. 47 C.F.R. § 15.205. *R&O*, *supra*, at para. 30-32. The restricted bands are bands allocated for the operation of radio services used for safety-of-life applications or radio services that, by the nature of their operation, require the reception of very low signal levels. There are sufficient spaces between the restricted bands to permit the operation of narrowband Part 15 systems. Accordingly, unlike UWB devices, there is no necessity to permit narrowband systems to operate in the restricted bands.

modulation types from consideration as UWB devices.[82]

46. Petition. Siemens VDO requests that we permit pulsed frequency hopping vehicle radars to be included under the definition of a UWB device by permitting such transmitters to occupy the minimum required bandwidth within any 10 millisecond period rather than at any point in time.[83] It argues that it provided the Commission with information on its frequency hopping system in its filing of November 13, 2001. Siemens VDO notes that this change would require a revision of the decision that frequency hopping systems must be measured with the frequency hop stopped.[84] Siemens VDO also requests that we revise the rules to permit emissions to be averaged over a 10 millisecond period instead of over a one millisecond period.[85] Siemens VDO indicates that the one millisecond averaging time required under the regulations is not long enough to permit an accurate RMS power measurement of pulsed frequency hopping systems that require a longer period to complete a hopping cycle and that too short an averaging time would result in higher measured values. Siemens VDO adds that the Earth Exploration Satellite Service (EESS) systems at 23.6-24.0 GHz were the only identified potential interference victims of UWB radar systems operating in the 22-29 GHz band and that these systems employ integration times which are too long to distinguish between pulsed and pulsed frequency hopping modulation types.[86] Siemens VDO provides a technical analysis to support its request to permit measurements of emission levels averaged over a 10 millisecond period with the system hopping in frequency.

47. Comments. SARA fully supports the Siemens VDO petition.[87] No other comments regarding the Siemens VDO petition were filed.

48. Discussion. The Commission specifically declined to include UWB systems under its rulemaking proposal if those systems employed linear sweep or similar modulations to achieve the wide bandwidths.[88] Accordingly, the type of modulation being addressed by Siemens VDO was not considered in the notice and comments leading to the adoption of the UWB regulations. Siemens VDO correctly indicates that SARA presented the Commission with the details of a frequency hopping radar system in an *ex parte* presentation submitted on November 13, 2001. However, that *ex parte* filing was not submitted until over one year after the comment response period to the *Notice of Proposed Rule Making* in this proceeding had ended, did not specifically state that Siemens intended to use of this type of modulation, and proposed no new procedures for the measurement of emissions from this equipment. Furthermore, there has been no indication by the Commission that it would consider arguments on this issue. Thus, there was no opportunity for the public to comment on Siemens VDO's proposal to produce a vehicular radar system using frequency hopping techniques. [89] Accordingly, the inclusion of a

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82 *Notice*, *supra*, at para. 21.

83 Siemens VDO Petition for Reconsideration at pg. 5-6.

84 *Id.* at pg. 6-8. Also, *R&O*, *supra*, at para. 32.

85 Siemens VDO Petition for Reconsideration at pg. 4 and 8-10.

86 *Id.* at pg. 13-14. It should be noted that there is a wide range of integration times possible for space borne passive sensors. For example, the AMSR sensor has a 2.6 millisecond integration time in the 23.6-24.0 GHz band. However, the AMSU-A sensor has an integration time of 158-165 milliseconds.

87 SARA comments at pg. 7-10.

88 *Notice*, *supra*, at para. 21.

89 The Commission also was not aware that this was Siemens VDO's intent. As noted in para. 270 of the *R&O*, *supra*, the Commission indicated that Delphi intended to manufacture a vehicular radar employing a pseudo-noise direct sequence binary phase shift keyed waveform and that SARA had expressed interest in a similar technology. The Commission indicated that this type of modulation would be acceptable under the UWB standards (continued....)

frequency hopping modulation technique at this time is beyond the scope of the issues addressed thus far in this proceeding. For this reason, we are denying Siemens VDO's Petition for Reconsideration. We are, however, addressing Siemens VDO's request in the Further Notice of Proposed Rule Making so that a public comment record may be obtained.[90] We also recognize that Siemens VDO currently has a request for waiver pending before the Commission that would permit the operation of the system described in its petition. This waiver request is under active consideration. While some analytical work remains to be completed, we intend to act expeditiously on the Siemens VDO waiver request.

5. Indoor UWB operation

49. The rules permit UWB devices to be operated indoors for any purpose provided the -10 dB bandwidth is within the 3.1-10.6 GHz band. These systems are permitted to operate at the Part 15 general emission limits, -41.3 dBm in the subject band, and are required to attenuate their emissions outside of this band. Within the 960-1610 MHz band, the emissions may not exceed -75.3 dBm, a level 34 dB below the Part 15 general emission limits.

50. Petition. Kohler[91] filed a Petition for Partial Reconsideration requesting that we increase the emission limit for indoor UWB devices from the current limit of -75.3 dBm to a level of -53.3 dBm within the 960-1610 MHz band.[92] Kohler states that measurements are impractical at the present low limit since the lowest achievable noise floor is -82.3 dBm at 960 MHz and -84 dBm at 1610 MHz, based on the use of a preamplifier with a 5 dB noise figure which Kohler states is the best normally used in a compliance test lab. Because of this, Kohler states that it has been unable to obtain sufficient sensitivity to provide a measurement 10 dB above the noise floor and therefore cannot obtain accurate readings.[93] Kohler further argues that the limit for indoor devices appears excessively restrictive since this is the same limit applied to vehicle radars and to hand held outdoor UWB devices and building attenuation reduces the emissions from the indoor devices by 9 dB, reducing interference to U.S. Government radio operations.[94]

51. Comments. AWS objects to increasing the emission level from Kohler's UWB radar, stating that Kohler's analysis is focused solely on potential interference to Government systems outside of buildings and fails to take into account potential interference inside the building to PCS and to cellular operations.[95]

52. Discussion. We do not agree with Kohler's requested changes to the indoor UWB emission limits. With regard to the measurement at the current limits, our laboratory personnel have made several measurements at and below the adopted limits. This required the use of two preamplifiers

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(...continued from previous page)
and rejected the swept frequency radar system also contemplated by Delphi. A frequency hopping system similarly would have been rejected.

[90] While we have some concerns regarding the test procedure proposed by Siemens VDO, we will address this issue under the Further Notice of Proposed Rule Making.

[91] Kohler manufactures a toilet ventilating device that installs in the water chamber of a toilet and is activated by UWB radar upon detecting a person sitting down. Currently, this equipment is certified under a waiver of our regulations that was issued by the Chief Engineer on August 6, 2001. It operates with an emission centered at 5800 MHz. Kohler's waiver is scheduled to expire on July 15, 2003.

[92] Kohler Petition for Partial Reconsideration at pg. 2.

[93] *Id.* at pg. 3.

[94] *Id.* at pg. 2 and 4.

[95] AWS comments at pg. 11.

before the spectrum analyzer, the first preamplifier being a low noise amplifier.[96] While the measurement is difficult, it is not impractical, and measurements at this low emission level are required over only a small portion of the radio spectrum.

53. With regard to Kohler's claim that building attenuation will provide sufficient attenuation to protect Government radio operations, Kohler neglects to consider that systems located within a building can operate at increased elevations, increasing the likelihood of potential interference to some nearby Government systems even with additional attenuation provided by the building.[97] Further, Kohler does not address radio operations which may require reception within a building. For example, the 1240-1300 MHz band is allocated to the Amateur Radio Service, the 1395-1400 MHz and 1429-1432 MHz bands are employed in the Wireless Medical Telemetry Service, and the 1432-1435 MHz band is allocated to the Private Land Mobile Radio Services.

54. In addition to our concerns expressed above, we continue to believe that major changes should not be made to the UWB rules until more experience is gained with the operation of UWB devices. Accordingly, Kohler's Petition for Reconsideration is denied. However, we note that Kohler currently is operating under a waiver of our regulations and that this waiver has been extended until one year from the effective date of the UWB regulations. This time period provides Kohler the opportunity to investigate changes to the design of its product.

B. Petitions for reconsideration from representatives of the authorized radio services:

1. UWB emissions in the Cellular and PCS frequency bands

55. The Cellular Radiotelephone Service operates at 824-849 MHz and 869-894 MHz; the PCS operates at 1850-1910 MHz and 1930-1990 MHz. UWB devices do not operate with their -10 dB bandwidths located within the PCS bands. However, like many other radio transmission systems, they may place unwanted emissions within that spectrum.

56. Petitions. Cingular, Qualcomm and Sprint each express strong objections to the UWB technical standards adopted in the *R&O*.[98] Cingular states that the cellular and PCS spectrum are exclusive bands and there was no reasonable basis for the Commission to change its policy by allowing UWB operation when such operation was not permitted under the previous Part 15 rules.[99] Cingular also states that the entire UWB decision should be reconsidered because it was not based on an adequate analysis of the interference that would be posed to cellular and to PCS.[100] Cingular adds that the Commission rejected all of the evidence supplied concerning the operating levels used by PCS systems. It also states that: 1) interference to PCS occurs from any device that causes a 1 dB increase in the receiver thermal noise floor, and UWB emissions at 12 dB below the Part 15 general emission limits

[96] Two initial preamplifiers have been employed, one with a 0.5 dB noise figure and a second with a 1.0 dB noise figure. The use of two preamplifiers requires that a tunable bandpass filter be employed to avoid overloading the instrumentation.

[97] *See*, for example, Tables 6 and 7 of the *Order*, *supra*.

[98] On December 20, 2002, Ericsson Inc. submitted a technical analysis regarding UWB interaction with PCS and other authorized stations. Ericsson referred to this filing as an *ex parte* submission. However, we do not find any new information within the Ericsson analysis and find no reason to justify a new comment and evaluation process.

[99] *Id.* at pg. 16-19.

[100] Cingular Petition for Reconsideration at pg. 5.

would cause interference to CDMA PCS systems;[101] 2) the Commission rejected Qualcomm's interference analysis based on systems operating at the -105 dBm thermal noise floor, whereas actual test data showed that received traffic signal strength could be as low as -118 dBm;[102] 3) there was no evidence that the staff considered signal levels used by TDMA or GSM PCS systems and the rejection of this information constitutes arbitrary and capricious rulemaking;[103] 4) UWB interference to PCS jeopardizes E-911 operations;[104] 5) the decision to permit UWB operation indoors was flawed because it assumed that building attenuation would provide additional protection, whereas PCS and cellular use indoors also are subject to building attenuation thereby needing lower UWB limits;[105] and 6) there is no correlation between UWB devices requiring AC power and in-building use since AC power can be obtained through the use of generators and long extension cords.[106] Cingular, believing that the Commission failed to address the interference potential of imaging systems to cellular operations, requests that we require through-wall imaging systems to operate above 60 GHz and that we require all other imaging systems, with the possible exception of GPRs, to operate above 2.7 GHz to minimize the impact on cellular, PCS and other terrestrial services.[107] It also requests that we require imaging systems to be capable of functioning only when they are in direct contact with a wall surface and to use automatic power control to ensure that operation is at the minimum possible power level. It argues that the Commission failed to provide a reasoned discussion as to why these requirements were not implemented. In addition, Cingular argues that the coordination process protects Government systems but provides no protection to cellular or PCS licensees, since the coordination information does not include specific locations, only operational areas, and cellular and PCS licensees will not receive notification of UWB devices within their areas.[108] Cingular requests site-by-site coordination with cellular and PCS users.

57. Qualcomm requests that the emission limits for UWB systems be revised to require that allowable emissions in the PCS band be the same as those permitted in the GPS band, *i.e.*, 34 dB below the Part 15 general emission limits, in order to protect E-911 communications.[109] It states that the Commission set emission limits for the PCS band without test data and that the regulations are fundamentally flawed as a matter of law since the Commission put the burden on Qualcomm to prove non-interference. According to Qualcomm, the Commission disputed that PCS handsets work near the -100 dBm signal level whereas Qualcomm's data verifies that PCS handset can operate at levels lower than -105 dB, in some cases as low as -106 dBm.[110] Qualcomm also states that the adopted UWB emission mask will result in a 5.58 dB degradation in signal-to-noise (S/N) at a 3 meter separation and a 13.9 dB degradation at a 1 meter separation, a separation distance Qualcomm believes to be realistic.[111] Qualcomm argues that the UWB signal must be 10 dB below the CDMA received power and recalculates the minimum separation as 4.52 meters based on the limits adopted by the Commission. Finally, Qualcomm requests that the Commission implement "transparent, collaborative tests of actual UWB

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101 *Id.* at pg. 5. Cingular indicates that UWB levels in the PCS bands should be 16-24 or even 27-35 dB below the Part 15 general emission limits

102 *Id.* at pg. 9.

103 *Id.* at pg. 12.

104 *Id.* at pg. 20-21.

105 *Id.* at pg. 14-15.

106 *Id.* at pg. 15.

107 *Id.* at pg. 21-22.

108 *Id.* at pg. 22-24.

109 Qualcomm Petition for Reconsideration at pg. 3-6, 13.

110 *Id.* at pg. 4, 7-9.

111 *Id.* at pg. 9-12.

devices with the complete participation and input of interested parties from the public and private sector to determine the full extent of the harmful interference from UWB devices to all existing communications services."[112]

58. Sprint's objections are similar to those of Cingular and Qualcomm. Sprint states its belief that the *R&O* is fraught with so many errors, legal and factual, that the Commission should voluntarily stay the effective date.[113] It contends that: 1) the conclusion in the *R&O* that PCS licenses are not exclusive is unexplained and inconsistent with Commission precedent;[114] 2) there is a legal error in that the burden of proof of non-interference was left to the licensees, the Commission did not consider the E-911 test data submitted by Qualcomm and ignored the Telcordia model as well as the Sprint January 30, 2002, ambient noise study comparing narrowband and UWB emissions, and the Commission misinterpreted test data;[115] 3) the Commission did not address the additional loss of network coverage and capacity that would result from PCS base stations having to transmit at higher power levels to overcome the noise produced at PCS handsets by UWB emitters;[116] 4) more protection is needed for indoor PCS reception and the Commission was arbitrary and capricious in setting a higher UWB indoor emissions limit than the limit for outdoor operation;[117] 5) the *R&O* conflicts with the Commission's E-911 rules and policies as protection similar to that given to GPS was not provided to PCS;[118] 6) UWB emissions in the PCS bands are spurious emissions and could have been reduced further without affecting the UWB transmission;[119] and 7) UWB emissions in the PCS bands should have been adjusted for a cumulative effect from multiple UWB transmitters.[120] Sprint takes exception to the various interference analyses performed by the Commission. It objects to the statement in the *R&O* that it is likely that UWB emissions would be somewhat below the maximum permitted limit, stating that there was no record evidence supporting this.[121] It also objects to the Commission's statement that interference at close distances could be remedied by moving the devices a short distance apart.[122] The Sprint petition also contains two attachments that provide a mathematic analysis of UWB interference to PCS systems and discuss the earlier analyses and tests. In Attachment 1, Sprint states that PCS handsets receive in-cell and other-cell interference from other PCS stations that add to the receiver thermal noise to result in a noise

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112 *Id.* at pg. 5-6, 13.

113 Sprint Petition for Reconsideration at pg. 3-4.

114 *Id.* at pg. 4-8.

115 *Id.* at pg. 8-10. The Telcordia model was presented by Sprint as Attachment 1 to its September 12, 2000, comments to the *Notice*. *See A Model for Calculating the Effect of UWB Interference on a CDMA PCS* System, September 12, 2000, by Dr. Jay Padgett, Senior Research Scientist with Telcordia Technologies. The Sprint study on narrowband versus UWB emissions was presented by Sprint as an *ex parte* filing submitted immediately prior to adoption of the *R&O*. *See Ambient Office Noise/Personal Computers and the Relative Impact of UWB Devices*, January 18, 2002, by Sprint PCS.

116 *Id.* at pg. 10-14. As total downlink power is fixed, less power would be available to serve other PCS handsets.

117 *Id.* at pg. 14-19.

118 *Id.* at pg. 20-26.

119 *Id.* at pg. 26-27.

120 *Id.* at pg. 27-29.

121 *Id.* at pg. 10-11.

122 *Id.* at pg. 11. The reference by Sprint was to a statement by the Commission finding that harmful interference between a UWB device and a PCS station did not occur until the separation distance between the two units was less than one meter and that it would be unlikely that UWB devices would be located this close to a PCS receiver.

plus interference level on the order of -98 dBm and that this noise plus interference level still allows the PCS receiver to operate with a desired signal level 6 dB below the thermal noise floor, *i.e.*, -111 dBm;[123] that the forward link channels have jamming margins of 16 dB for pilot, 24 dB for sync, and 18 dB for paging;[124] that Rayleigh fading statistics are not appropriate for CDMA systems which use multi-branch RAKE receivers to coherently combine different multipath clusters as diversity branches to reduce fading variations;[125] and that a 1 dB increase in the effective noise floor will cause a non-negligible coverage degradation for outdoor handsets.[126] In Attachment 2, Sprint states that an anechoic chamber test was performed to confirm the sensitivity of handsets and to establish the free space coupling between a UWB emitter and a PCS handset, demonstrating that an S/N of about 5 dB was required for PCS operation;[127] that the outdoor test confirmed that the interference from the UWB emitter affected the PCS handset as predicted in the Telcordia model, causing the call to drop when the UWB emitter was less than one foot from the PCS handset;[128] that the total received signal power in the anechoic chamber was about -105 dBm with a -10.3 dB traffic power allocation resulting in a desired signal power of -115.3 dBm whereas in the field test the total signal power was at -94 dBm.[129] Sprint adds that the requirement for the UWB emitter to be less than one foot from the PCS receiver in order to cause it to drop the call should not be used as a measure of the immunity of PCS handsets as the total received power from the downlink, -94 dBm, was about 10 dB above the normal cell boundary signal level.

59. The overall point made by Sprint is that emissions from the UWB systems that fall within the PCS band should be attenuated to the same limit that is applied in the GPS band.[130] However, Sprint also wants additional protection for the GPS and PCS bands beyond what the Commission adopted in the *R&O*. Sprint objects to the Commission not providing the additional 8.4 dB of protection to the GPS bands sought earlier by USGPSIC. It requests that UWB emission limits be further decreased in the GPS bands by 6 dB as a safety factor to account for variables such as lower attenuation provided by certain buildings, by 6 dB to account for cumulative effects from multiple indoor UWB devices, and by 6 dB to account for greater sensitivity needed for satellite acquisition as opposed to satellite tracking.[131] It also requests that these limits be adjusted to provide protection at a separation distance of 1 meter instead of the 2 meters used in the *R&O*, resulting in an additional 6 dB attenuation requirement.

60. Sprint states that the Commission must require each UWB equipment developer participating in this proceeding to make multiple samples of their products available to industry for interference testing.[132] Sprint adds that the decision to exclude other UWB devices from the send/acknowledge requirements implemented for hand held UWB devices is unexplained, arbitrary and capricious, as is the 10-second time period during which acknowledgement of reception must occur.[133] It states that the send/acknowledgement requirement also should apply to indoor UWB devices and that it should be based on a 3 or 5 second time period. In addition, Sprint requests that surveillance systems be

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123 *Id.* at pg. 4, Attachment 1.

124 *Id.* at pg. 10, Attachment 1.

125 *Id.* at pg. 19, Attachment 1.

126 *Id.* at pg. 23, Attachment 1.

127 *Id.* at pg. 1, Attachment 2.

128 *Id.* at pg. 2, Attachment 2.

129 *Id.* at pg. 6-7, Attachment 2.

130 *Id.* at pg. 21.

131 *Id.* at pg. 22-25.

132 *Id.* at pg. 36-39.

133 *Id.* at pg. 35-36. *See*, also, 47 C.F.R. § 15.519(a)(1).

subject to the same standards as indoor or outdoor UWB devices with operation allowed only above 3.1 GHz.[134] Sprint argues that surveillance systems are not imaging systems and that the Commission never explained why they should be treated as such or why they should be permitted to operate in the 1.99-10.6 GHz band. It also requests that we place additional restrictions on who is permitted to operate surveillance systems, limiting operation solely to law enforcement, fire, and emergency rescue personnel until UWB proponents document that their systems will not pose a risk of harmful interference.

61. Comments. *Exclusivity.* Time Domain comments that the PCS carriers have licenses to provide PCS service within a given band, in a specific area, for a defined term; their licenses are exclusive only in the sense that no other carrier would be allowed to provide PCS service in the same band, in the same area, at the same time.[135] XSI cites *AT&T Wireless Services, Inc. v. FCC*, 270 F.3d 959, 964 (D.C. Cir. 2001) stating that this case affirmed the Commission's decision that even an exclusive licensee cannot object to secondary use of its spectrum as long as no harmful interference results.[136] XSI also notes that UWB does not operate in the PCS bands but only places out-of-band emissions there, as do transmitters in many services with most at higher levels that permitted for UWB.[137] XSI adds that PCS carriers knew before placing their bids on the spectrum that Part 15 devices were permitted to transmit in the PCS bands, and at higher levels than those adopted for UWB devices.[138] Finally, XSI notes that the only relevant point in *Public Utility Commission of Texas*, 13 FCC Rcd 3460, 3503 ¶ 89 (1997), as raised by Sprint,[139] is that PCS licensees have exclusive rights to their spectrum against other licensees.[140]

62. USGPSIC argues that permitting UWB operation within the PCS bands violates clear Commission precedence and pronouncements regarding PCS exclusive access to the spectrum.[141] USGPSIC believes that the Part 15 rules apply only to narrowband operations for unintentional radiators that are not permitted to cause interference and therefore do not apply to UWB operations which are wideband and cause interference at the Part 15 levels.

63. In its reply comments, Sprint argues for exclusivity of the PCS spectrum, stating that the Commission cannot introduce new interference into the band.[142] It states that it does not own the spectrum but has a permit to use the spectrum supported by Government receipt of valuable consideration giving it contractual rights not possessed by those holding licenses acquired by comparative hearing or by a lottery. It adds that spurious emissions constitute use of the band and that new interference may not be introduced after it has built its network under the expectation that only traditional Part 15 devices would be permitted. Sprint states that there is an undisputed record that UWB devices will cause harmful interference to PCS.[143]

64. *UWB Emission Levels in the PCS Bands.* Time Domain states that the signal levels that Sprint opposes for UWB devices already are being generated by millions of electronic devices, often at

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134 Sprint Petition for Reconsideration at pg. 30-35.

135 Time Domain comments at pg. ii.

136 XSI comments at pg. 3, 7, 15-16.

137 *Id.* at pg. 3, 14, 16-17.

138 *Id.* at pg. 3, 15, 17-19.

139 Sprint Petition for Reconsideration at pg. 4.

140 XSI comments at pg. 14, 15-16.

141 USGPSIC comments at pg. 18-19.

142 Sprint reply comments at pg. 18-20.

143 *Id.* at pg. 21-23.

higher levels than set for UWB devices, and that the relevant inquiry is whether UWB will cause harmful interference.[144] Time Domain disputes Sprint's and Qualcomm's contentions that RAKE receivers eliminate Rayleigh fading, noting that the variation in the received signal level in Sprint's test data was due to multipath.[145] Time Domain submits that while RAKE receivers can reduce the impact of fading, it is unclear what gain is achieved in practice. Time Domain also notes that a UWB system operating above 3.1 GHz must be attenuated by 34 dB below the Part 15 general emission limits at 1.6 GHz, forcing the emission to be attenuated by at least 20 dB in the PCS frequency band.[146]

65. XSI disagrees with the complaints by the petitioners that the Commission failed to carry out its obligations, provided an inadequate analysis of interference, established an indoor UWB limit that was irrationally higher than the limit for outdoor UWB devices, and infringed on PCS licenses.[147] XSI disagrees with the petitioners' position that the Commission ignored evidence in the record, noting that the Commission provided twelve pages of text evaluating the major findings of all of the submitted studies and explaining any disagreements it had with those studies.[148] Accordingly, XSI believes that the petitioners do not challenge the adequacy of the Commission's analyses so much as the result.

66. XSI notes that the lower limits established for outdoor hand held UWB devices were established not to protect PCS but to protect U.S. Government radio systems on both sides of the PCS band, indicating that the lower emission limit applied over the 1610-3100 MHz band whereas PCS operates only within the 1850-1990 MHz portion of the band.[149] XSI believes that the petitioners, while disputing the Commission's approach on its calculation of the proper emission limit for UWB emissions in the PCS band, offer no evidence as to why the Commission's approach evaluated under actual operating conditions is wrong.[150] XSI disagrees with Sprint's statement that emissions in the PCS band could have been further attenuated because they are spurious emissions, noting that UWB devices have a shallow curve of emission attenuation and that implementing additional attenuation below 3.1 GHz would impair performance in other parts of the spectrum. With regard to the emission limits in the GPS band, XSI states that nothing in the Sprint petition justifies lower emission limits from UWB devices, noting that the adopted limit is what was requested by the USGPSIC[151] and that the specific limit already approaches the lower limit for practical measurements.[152] XSI provides a technical attachment addressing several issues, notably that the Commission provided a reasoned justification for its use of an emission level of -96 dBm;[153] that the PCS frame error rate would exceed the acceptable level of 2% because of even minor fluctuations in received signal power;[154] and that Qualcomm noted that a noise floor analysis

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144 Time Domain comments at pg. 5.

145 *Id.* at pg. 7-9.

146 *Id*. at pg. 9.

147 XSI comments at pg. 2.

148 *Id.* at pg. 10-13.

149 *Id.* at pg. 3, 13-14.

150 XSI indicated that these conditions included the effects from multipath fading, interference from other PCS base stations, sub-optimal antenna alignment, and signal attenuation due to the user's head and hands. XSI comments at pg. 20-22.

151 XSI references the July 16, 2001, letter from Raul R. Rodriguez, Counsel to the U.S. GPS Industry Council, to Magalie R. Salas, Secretary, FCC.

152 XSI comments at pg. 23-24.

153 *Id.* at pg. ii, Technical Statement.

154 *Id.* at pg. ii-iii, Technical Statement.

is not relevant, as the Commission earlier recognized.[155]

67. USGPSIC supports the petitioners, stating that uninterrupted operations are necessary to ensure a viable E-911 service.[156] USGPSIC opines that the Commission should adopt the emission levels requested by the petitioners, stating that they best understand the level of protection needed to achieve continuous service and that the Commission should err on the side of too much protection instead of too little.[157] AWS also supports the petitioners, stating that the petitions clearly demonstrate that the limits on UWB emissions in the PCS band are insufficient to protect existing PCS operations and are arbitrary and capricious since the rules are based on incorrect factual and legal premises and fail to account for significant record interference.[158] AWS states that PCS calls may be made based on a receiver sensitivity of -102 dBm and indicates that it is arbitrary and incorrect for the Commission to base its analysis on a signal level of -96 dBm/1.25 MHz.[159] AWS indicates that a 1 dB degradation to receiver sensitivity would reduce cellular coverage by 8-9 percent.[160] AWS objects to the Commission's statement in the *R&O* that it is unlikely that UWB devices will be located close to a PCS receiver, adding that equipment mobility makes it likely for these products to come into "contact."[161] AWS also states that interference could not be remedied by coordination, as coordination is impracticable for PCS users that cannot identify or locate the UWB device.[162] It also believes that the Commission, without explanation, was incorrect in providing higher emission levels for indoor UWB devices than for outdoor devices, and that the Commission provided no explanation for doing so.[163] It adds that protection similar to that provided to GPS is necessary for PCS due to its close proximity to the GPS band. AWS further believes that the *R&O* is flawed legally, stating that Part 15 only allows operations that pose no significant risk of harmful interference to licensed operations and that the Commission cannot authorize UWB emissions in licensed spectrum and require licensed spectrum users to engage in extensive efforts, *e.g.*, increasing separation, system coordination, or constructing new systems, to continue functioning.[164] It indicates that the Commission misapplied the burden of proof by requiring licensed spectrum holders to demonstrate a likelihood of interference rather than requiring the UWB proponents to demonstrate a lack of interference. AWS believes that the Commission should require UWB manufacturers to bear the cost of any alterations to the PCS system, *i.e.*, the construction of new base stations, necessary to mitigate interference.[165] AWS

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155 *Id.* at pg. iii, Technical Statement.

156 USGPSIC comments at pg. 2.

157 *Id.* at pg. 17-18.

158 AWS comments at pg. 1-3.

159 *Id.* at pg. 4.

160 *Id.* at pg. 8.

161 *R&O*, *supra*, at para. 159. AWS comments at pg. 5. What the Commission actually stated in the *R&O* at para. 159 was that interference between a UWB transmitter and a PCS handset at the adopted limit appeared to require the two devices to be separated by less than one meter and that it is unlikely that UWB transmitters would be located this close to a PCS receiver, particularly in light of the operating restrictions being applied to UWB devices. The Commission also stated that it did not believe that it was appropriate to use such a close separation distance as the basis for controlling harmful interference.

162 *R&O*, *supra*, at para. 55. AWS comments at pg. 8-9. The coordination process was insisted upon by NTIA so that imaging systems would not be operated near to-be-determined Government radio installations without prior notice. They were not implemented, nor were they needed, to provide additional interference protection to PCS operations.

163 AWS comments at pg. 10-12.

164 *Id.* at pg. 12-14.

165 *Id.* at pg. 16-17.

also asks that emissions in the PCS bands from indoor and outdoor UWB devices be reduced by an additional 6 dB to protect against the effects of cumulative emissions from multiple UWB devices, noting that the Commission provided such protection for UWB emissions appearing in the GPS bands, but not in the PCS bands.[166]

68. In its reply comments, Time Domain responds to the arguments from AWS and Sprint that PCS and cellular operations need additional protection indoors due to signal loss caused by building walls and windows.[167] Time Domain states that in the IS-95 system, the system controls the transmitted power level so that each handset, regardless of location, receives the same average power resulting in an indoor handset receiving the same power as an outdoor handset. Accordingly, no additional protection is needed for indoor PCS operations. With regard to the claims of the PCS proponents that the IS-95 system would have to increase transmitted power to compensate for the UWB signal, reducing system capacity, Time Domain states that real world experimentation showed that when the IS-95 handset was in close proximity, *i.e.*, from less than 1 up to 3 meters, the PCS system did not increase transmit power relative to when there was no UWB transmission. XSI argues that the AWS comments are untimely requests for reconsideration and references its earlier response to the petitioners.[168]

69. Qualcomm's reply comments reiterate many of the points raised in the petitions. It states that data showed that PCS phones operate near -105 dBm whereas the *R&O* only provided protection to a -96 dBm signal.[169] It also argues that XSI's claim that earlier data did not show characteristic Rayleigh fades was inaccurate.[170] In response to the comments from Time Domain, Qualcomm states that it is the sensitivity of the PCS phone that allows operation below -105 dBm, depending on the noise figure of the receiver, and not the RAKE receiver processing.[171] Finally, Qualcomm notes that its principle concern in this proceeding is not and never has been interference from UWB devices to PCS phones in a mobile indoor scenario but instead is based on a stationary scenario such as someone inside an office with poor coverage trying to call 911 while surrounded by UWB devices in close proximity being used for wireless local area networks, etc.[172]

70. Sprint, in its reply comments, summarizes the points raised in its petition as to its claim that the Commission made errors in the *R&O*.[173] It states that: 1) because of the spreading gain inherent in the CDMA air interface, the PCS handset has a sensitivity on the order of 13 dB below the thermal noise floor of the handset;[174] 2) considering the effects of other-cell interference, in-cell interference, and thermal noise, as well as the signal-to-interference plus noise ratio requirements for the overhead channels, a total received power from each base station that is near the thermal noise floor at the edge of the cell coverage area is a logical design; 3) that even fairly small increases in the effective noise floor can significantly degrade PCS network coverage; 4) that assertions that the open field tests were inconsistent with the Telcordia Model and the anechoic chamber tests were factually inaccurate; 5) that the Telcordia model did take into account the effects of other-cell interference; 6) that the effect of a

166 *Id.* at pg. 18.

167 Time Domain reply comments at pg. 5.

168 XSI reply comments at pg. 1.

169 Qualcomm reply comments at pg. 2.

170 *Id.* at pg. 2-3.

171 *Id.* at pg. 6.

172 *Id.* at pg. 7.

173 Sprint reply comments at pg. 4-6.

174 The 18 dB processing gain combined with the need for a S/N of 5 dB results in the sensitivity of the receiver being 13 dB below the thermal noise floor.

given UWB interference level on coverage reduction is the same, whether or not fading is taken into account; 7) that fading statistics normally are much less severe than indicated by the Rayleigh model due to use of the RAKE receiver; and 8) that frame errors occur at even high signal levels and will occur on a regular basis even in a static situation. Sprint states that Time Domain acknowledged that the emission limit in the PCS band on indoor UWB devices could be tightened by 15 dB without a negative impact on UWB devices and that XSI does not identify any of its products that would be impaired by this attenuation.[175] Because of this, Sprint requests a limit on emissions in the PCS band from indoor UWB devices of -68 dBm. Sprint also states that the Commission presented no explanation for its choice of a limit of -53.3 dBm in the PCS band for indoor UWB devices and could not have relied on the staff analysis since that analysis was not submitted into the public record until May 3, 2002, 2 weeks after the release of the *R&O*, strongly suggesting that the staff analysis was not completed until after the *R&O* was released.[176] Sprint reiterates its request that the Commission provide additional safety margins to the GPS band to account for uncertainties, cumulative effect, and satellite acquisition and to apply the same protection to PCS.[177] Sprint believes that XSI's claim that UWB devices in close proximity must take turns operating is inaccurate and unsupported, believing that many channels can be supported simultaneously in the same spectrum.[178]

71. Sprint responds to specific statements from Time Domain and XSI in Attachment 3 to its reply comments. It asserts that: 1) the supposition that fading somehow masks the effect of external interference is incorrect, adding that an increase in the effective noise floor translates directly to an increase in the required received signal power;[179] 2) the orthogonality of the received signal plays no role in the relationship between the level of UWB interference and the required increase in downlink traffic channel power, adding that the additional received traffic channel power required to compensate for the UWB interference is I_{UWB}/M where I_{UWB} is the UWB interference power received by the handset and M is the jamming margin;[180] 3) a PCS handset has a sensitivity on the order of 12 dB below the thermal noise floor of the handset, -105 dBm based on a KTB[181] calculation plus an 8 dB noise figure, and the -96 dBm limit at the cell boundary includes all power from the PCS system, not the power of a single cell;[182] and, 4) the Commission ignored the Telcordia study as well as Sprint's ambient noise study.[183]

72. *Need for Additional Test Data.* AWS states that interference tests of real UWB devices should be conducted and all interested parties, particularly licensees likely to encounter UWB interference, be allowed to participate in the design and implementation of the testing process.[184] AWS

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175 *Id.* at pg. 7-9.

176 *Id.* at pg. 10-11. Also, Sprint reply comments, Attachment 3 at pg. 12.

177 *Id.* at pg. 12-13. Sprint does not explain the inconsistencies between its request for a -68 dBm limit on emissions appearing in the PCS bands from indoor UWB devices and its request to apply the same limits in the PCS band as the lower limits applied to UWB emissions in the GPS bands.

178 *Id.* at pg. 13-16.

179 *Id.*, Attachment 3 at pg. 3.

180 *Id.* at pg. 4.

181 "KTB" is the reference to the standard calculation for determining the noise floor of a receiver. K is Boltzmann's constant equal to 1.38×10^{-23} W/Hz/ºK, T is temperature in degrees Kelvin, and B is the receiver bandwidth in Hertz. For a standard temperature of 290º K, the receiver noise floor is -174 dBm/Hz, or -114 dBm/MHz, plus the noise figure of the receiver. The 1.25 MHz PCS receiver bandwidth and 8 dB noise figure results in a noise floor of -105 dBm.

182 *Id.* at pg. 5.

183 *Id.* at pg. 7.

184 AWS comments at pg. 19.

adds that it is a basic principle of administrative law that the Commission cannot rely as a basis of its rules on the results of tests carried out without public participation. Time Domain notes that it engaged in testing UWB interference with multiple opportunities for interested parties to comment on the test design.[185]

73. *Imaging Systems/Coordination.* AWS requests that existing broad user categories, such as "industrial entities" for surveillance systems, be removed, and that operation be limited to use for public safety purposes.[186] In its reply comments, Sprint reiterates its claim that surveillance systems are not imaging systems and should be reclassified with different emission limits.[187]

74. Discussion. *Cellular and PCS Exclusivity of Operation*. There is no basis for Sprint's and Cingular's claim that cellular or PCS exclusivity prohibits the Commission from providing for the operation of new radio services, including the operation of UWB devices that could place emissions within these bands. The argument that UWB is a new Part 15 operation is not relevant. As noted by XSI, *AT&T Wireless Services, Inc. v. FCC*, 270 F.3d 959, 964 (D.C. Cir. 2001) affirmed the Commission's decision that even an exclusive licensee cannot object to secondary use of its spectrum as long as no harmful interference results.[188] As further pointed out by Time Domain and by XSI, the cellular and PCS licenses are exclusive in the sense that no other carriers will be allowed to provide cellular or PCS service in the same frequency band, in the same area, and at the same time. The definition of exclusivity Sprint and Cingular are requesting would result in halting the further development of new radio services and applications. For example, there could be no Advanced Wireless Services (3G) operations nor could SDARS, DTV, an expanded MMDS and ITFS, or any other new communication system be permitted as all of these systems are capable of placing low levels of emissions in the frequency bands allocated for PCS. As we demonstrate in the following paragraphs, emission levels have been established for UWB devices such that the operation of these products will not result in harmful interference to cellular or to PCS operations. This is sufficient to satisfy our obligation to the cellular and PCS carriers for exclusivity of use that will enable them to efficiently and effectively provide the services they are licensed to offer.

75. *UWB Emission Levels in the PCS Bands*. We do not concur with the petitioners that a decrease in the UWB emission limits is necessary to protect PCS radio systems from harmful interference. Sprint provides extensive analyses of the effect of RF noise on PCS operation. Qualcomm also demonstrates that nearby UWB emitters could degrade the signal-to-noise ratio at the PCS receiver. However, these studies simply demonstrate that any increase in the noise floor of a receiver will result in a decrease in the maximum range at which the receiver can receive communications. We do not dispute these facts. However, we disagree that the small increase in the noise level provided by nearby UWB

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185 Time Domain reply comments at pg. 6.

186 AWS comments at pg. 15.

187 Sprint reply comments at pg. 16.

188 The D.C. Circuit in *AT&T Wireless v. FCC*, 270 F. 3d 959, 964 (D.C. Cir. 2001), order on remand, *Aircell Inc.*, FCC 02-324 (rel. Feb. 10, 2003), rejected a similar claim of exclusivity alleged by wireless carriers. The Court held that an alleged exclusive licensee cannot object to secondary use of its spectrum so long as no harmful interference exists. In particular, 47 C.F.R. § 22.911(d) provides that the "exclusive[]" assignment of channels provided for in 47 C.F.R. § 22.905 entitles each cellular licensee, within its CGSA, to protection of its system from co-channel and first adjacent channel interference and from the capture of its subscriber traffic by adjacent cellular systems using the same channel block. Pursuant to 47 C.F.R. § 22.911, cellular licensees with adjacent systems must cooperate by changing channels used at specific cell cites or by other technical means, to resolve any co-channel interference. In other words, under the Commission's applicable rules, any "exclusivity" the wireless carriers may have applies only with regard to other wireless carriers, but that does not preclude the Commission from approving new services that do not otherwise affect operationally the wireless carriers' operations (on remand, the Commission found no interference to the wireless carrier's operations), which is the case here.

emitters represents harmful interference.[189] We also disagree with the petitioners that interference from the operation of UWB devices would require the construction of new PCS base stations.

76. As discussed below, we do not believe that the analyses or claims of the petitioners establish that greater attenuation is necessary to prevent harmful interference to PCS systems. In cellular CDMA systems, it is a well known fact that cell coverage, capacity and noise are closely related to one another. The capacity of a cell is in inverse proportion to the available coverage area of the cell. Further, any increase in the background noise level will have an impact on both cell coverage and capacity.[190] Because no radio systems operate in a noise-free environment, cellular providers must recognize that background noise from other radio frequency sources exists and design their systems to accommodate this noise in order for the cellular system to function. Indeed, as Sprint recognized in its petition PCS transmitters themselves generate noise into their own and into other PCS systems. Sprint's technical analysis of the impact to PCS operation from UWB devices assumes that most PCS handsets will be operating next to a UWB device, that the emissions from the UWB device in the PCS band will be at the maximum limit permitted under the UWB standards, that these emissions will be directed towards the PCS handset without intervening objects and will be perfectly coupled with the handset antenna, etc. However, this is not the case. As is the case with the interaction of PCS devices with other RF radiators, including Part 15 devices as well as other devices in the authorized radio services that also radiate within the PCS band, any impact on the PCS services will be rare and localized to an individual handset; there will not be an impact to the overall PCS system.

77. Determining the separation distance necessary to prevent harmful interference is not an exact science. It is dependent on several variables, some of which are described in the following paragraphs. When the interference analysis was performed for the *R&O*, the Commission did not employ the processing gain, or interference jamming margin, of the CDMA PCS emission nor did it address the in-cell and other-cell background noise level. Rather, an analysis was employed following the format provided by Qualcomm in its comments to the *Notice*. It is a simple matter to approach the interference analysis from another direction. There are different methods that could be used to perform these calculations. For example, Cingular argues that interference to PCS reception results from any device that causes a 1 dB increase in the receiver noise floor.[191] However, this ignores the processing gain incorporated within the receiver and the increase to the PCS receiver noise level from in-cell and other-cell PCS signals. Further, we do not agree that a 1 dB increase in the noise floor of a mobile receiver is indicative of harmful interference. Any signal level, no matter how small, will result in some increase in the receiver noise floor. Mobile systems normally must accommodate a much higher increase in the receiver noise floor than 1 dB for the signal to be considered harmful interference. Indeed, the Commission previously rejected the use of small increases to the noise floor for determining the presence of harmful interference, believing this method of analysis to be unduly pessimistic.[192]

78. The petitioners provided several specifications relating to the operating characteristics of PCS systems. The thermal noise level of any receiver, in dBm/MHz, is equal to 10 log (Boltzman's constant of 1.38×10^{-23} W/Hz/ºK times the temperature in degrees Kelvin) + 90 dB + the noise figure of the receiver. The temperature employed for terrestrial receivers is 290º Kelvin, and the noise figure for a

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[189] As stated in para. 161 of the *R&O*, *supra*, the Commission earlier disagreed with Qualcomm that a 1 dB increase in the system noise floor, equivalent to a I/N of -6 dB, is indicative of harmful interference to a communication system.

[190] For example, if S/N is increased from 6 dB to 7 dB the cell capacity will decrease from 31 to 25. *See IS-95 CDMA and cdma2000*, Vijay K. Garg, Prentice Hall PTR, 2000, at pg. 288.

[191] Sprint stated that a 1 dB increase in the effective noise floor will cause a non-negligible coverage degradation for an outdoor PCS receiver.

[192] *Second Memorandum Opinion and Order* in WT Docket No. 99-168, 16 FCC Rcd 1239 (2001) at para. 6-8.

cellular receiver is 8 dB.[193] Thus, the thermal threshold for a cellular receiver is -106 dBm/MHz.[194] As determined by Sprint and Qualcomm in comments filed in response to the *Notice*,[195] the antenna gain of a PCS handset is -4.6 dB and the PCS receiver line loss is 2 dB.[196] According to Sprint, the PCS handset provides 19.4 dB of processing gain and requires a S/(N+I) of 6.2 dB.[197] Thus, in the absence of outside noise sources the PCS receiver has an operational sensitivity level of -112.6 dBm/MHz.[198] This sensitivity level is based only on the presence of thermal noise. Sprint also indicated that its link budget is based on a receive sensitivity of -106 dBm/MHz.[199] As indicated by Sprint in its petition, in-cell and other-cell interference from other PCS stations, when added to the receiver thermal noise, results in a noise plus interference level on the order of -99 dBm/MHz. However, we disagree that operation of a PCS system can occur at these stated parameters outside of a laboratory or other controlled environment. The following link budget analysis is used to demonstrate this.

Parameter	Value	Equation
Frequency	1900 MHz	F
Receiver antenna gain	-4.6 dBi	AG
PCS receiver line loss	-2 dB	LL
Desired signal level	-106 dBm/MHz	DSL
Received desired signal level [200]	-112.6 dBm/MHz	S = DSL + AG + LL
Processing gain	19.4 dB	PG
Minimum required S/(N+I)	6.2 dB	S/(N+I)
Maximum N+I	-99.4 dBm/MHz	MaxNI = S + PG – S/(N+I)

[193] This receiver noise figure was provided by Qualcomm in its report submitted in this proceeding on March 5, 2001. *See*, also, Sprint Petition for Reconsideration, Attachment 1, at pg. 4.

[194] The -105 dBm value cited by the petitioners is based on a bandwidth of 1.25 MHz. As the UWB emission limits are based on the average signal level in a 1 MHz bandwidth, it is convenient to reference all emissions to the same 1 MHz bandwidth.

[195] *See* FCC staff analysis entitled "ET Docket No. 98-153, First Report and Order, Potential Interference to PCS from UWB Transmitters Based on Analysis from Qualcomm Incorporated," February 14, 2002, that was placed in this comment file for this proceeding.

[196] For example, a -100 dBm PCS signal level would be received at the receiver antenna terminals as a level of -106.6 dBm.

[197] Sprint Petition for Reconsideration, Attachment 1, at pg. 4. We note that the processing gain specified by Sprint is based on the use of a Rate Set 2, *i.e.*, a 1/2 rate convolution encoder on the reverse link, whereas a Rate Set 1, *i.e.*, a 1/3 rate convolution encoder provides a processing gain of 21.1 dB. Both processing gains are supported by IS-95. *See* Literti, Joseph C. Jr. and Rappaport, Theodore S., *Smart Antennas for Wireless Communications: IS-95 and Third Generation CDMA Applications*, 1999, at pg. 52-53 and 136. While Qualcomm, in its petition, stated that the UWB signal must be 10 dB below the CDMA received power, it gave no reason for providing this new value nor why the earlier test data submitted by Qualcomm demonstrating the need for a 6 dB S/I is no longer applicable. A 10 dB S/I was used in the staff analysis to reflect the conditions specified in the *Second Memorandum Opinion and Order* in WT Docket No. 99-168, 16 FCC Rcd 1239 (2001); this analysis was rejected by the petitioners.

[198] Sprint cited a handset sensitivity of -118.2 dBm/1.25 MHz, equivalent to -119.2 dBm/MHz, but did not consider the 6.6 dB of loss due to the handset antenna gain and line loss. We recognize that the accuracy implied from calculating emission levels based on tenths of a dB may be misleading. Propagation calculations are approximations. We are not attempting to insinuate that the calculations have this level of accuracy.

[199] Sprint Petition for Reconsideration at pg. 12. Sprint did not indicate whether this sensitivity level, stated as -105 dBm, was based on the signal level at the receiver input terminals or on the emission level at the antenna of the receiver. However, its text leads us to believe that this level is based on the emission level at the antenna of the receiver.

[200] This is the signal level at the antenna terminals, not at the antenna.

79. As shown above, the maximum noise plus interference level that can be tolerated by a PCS handset receiving a PCS signal at a level of -106 dBm/MHz is approximately -99 dBm/MHz. If the in-cell and other-cell noise levels are high enough to produce a noise plus interference level of -99 dBm/MHz, there is no margin to accommodate noise from any other source, including noise generated by multipath of the intended PCS signal or noise produced by another nearby RF device. Indeed, under these conditions the introduction of noise from another PCS handset operating in an adjacent frequency block, *e.g.*, under the control of another PCS carrier, could affect PCS system reliability, even if the second PCS handset was 100 meters away.[201] The same interference concern would exist for a PCS handset operating under these parameters if it is located within 50 meters of a consumer microwave oven.[202]

80. Sprint provided information in its petition on the level of noise produced from multipath due to the PCS handset operator walking at a slow pace.[203] In Attachment 1 of the Sprint petition, Figure 11 contains an example of a Rayleigh-faded PCS signal for a walking speed of 2 mph; Figure 12 shows that same signal after the output of a 3-branch maximal ratio combiner contained within the receiver. We note that the difference in Figure 12 between the signal peak and the null after the combiner is about 17 dB, with the lowest signal null about 12 dB below the median received level and two other nulls of about 8 dB below the median received signal level. If the median received signal is -106 dBm/MHz, as indicated by Cingular and Sprint as typical towards the PCS cell edges, and the effect of the PCS in-cell and other-cell emissions is to produce a noise plus interference level in the PCS receiver of -99 dBm/MHz, no margin exists to permit the reception of a lower level PCS signal and the nulls below the median signal level due to multipath could affect system reliability. We note that multipath problems would be more severe for PCS handsets moving at a greater speed, such as in a vehicle. We also note that the RAKE receiver that is used in PCS systems to reduce multipath may not be effective on eliminating multipath problems for systems operated indoors where the multipath delay spreads can be much smaller than the IS-95 chip duration of about 800 nanoseconds.[204] Accordingly, the operation of a PCS handset in a moving vehicle or the operation of a PCS handset indoors is likely to be even less reliable under the conditions specified by Sprint.

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[201] PCS handsets are permitted to operate with spurious emissions into adjacent frequency blocks as high as -13 dBm/MHz. *See* 47 C.F.R. § 24.238(a). With an antenna gain of -4.6 dBi, as described above, the radiated signal level from that handset, based on free space propagation, at a distance of 100 meters will be -95.6 dBm/MHz. If the noise plus interference level in a PCS receiver already is at -99 dBm/MHz, the introduction 100 meters away of another PCS handset operating in an adjacent PCS frequency block could increase the noise plus interference level in the first PCS receiver from -99 dBm/MHz to -97.3 dBm/MHz, 2.1 dB above the maximum noise plus interference level that can be accommodated. The emission level permitted by a PCS transmitter into adjacent PCS bands at 100 meters is the same as that permitted from an indoor UWB device, operating in the PCS band at its maximum permitted emission limit, at a distance of only 1.6 meters. Accordingly, PCS transmitters operating in adjacent frequency blocks represent a considerably greater threat of harmful interference to PCS operation than do UWB devices. We recognize that PCS transmitters may not emit signals at the maximum limit permitted under our rules, but there is the same probability that UWB devices also will not emit at the maximum limit within the PCS band.

[202] A 1500 W microwave oven is permitted to radiate a signal level of 43.3 uV/m at 300 meters. *See* 47 C.F.R. § 18.305. Using free space propagation, the emissions from the microwave oven are permitted to produce the same signal level at 57 meters as that permitted from a PCS transmitter at a distance of 100 meters, *i.e.*, a signal level of -95.6 dBm/MHz EIRP. As before, this would result in a noise plus interference level that is 2.1 dB above the maximum noise plus interference level that can be accommodated under the parameters specified by Sprint.

[203] Sprint Petition for Reconsideration at Attachment 1, pg. 19-20.

[204] *See* Rappaport, Theodore S., *Wireless Communications, Principles and Practice, Second Edition*, 2002, at pg. 391-393. 800 nanoseconds represent an additional path length of 240 meters.

81. As demonstrated above, a PCS system may not be reliable at the extreme operating conditions specified by Sprint. Either the minimum PCS received signal level must be increased above -106 dBm/MHz or the level of the PCS in-cell and other-cell noise must be reduced in order to ensure functionality of the PCS system in an environment that produces multipath interference. We expect that adjustments to both emission levels are necessary. Unfortunately, no measurement data has been incorporated in this proceeding that demonstrates an appropriate level for in-cell and other-cell PCS emissions.[205] Further, the petitioners insist that their systems are designed to operate at a signal level of -106 dBm/MHz. However, it is possible to demonstrate that harmful interference would not occur to PCS systems from nearby UWB devices even under these extreme conditions. To reiterate the parameter specified by Sprint in its petition, "the handset receives in-cell and other-cell interference, which add to the thermal noise and results in a noise plus interference level on the order of -98 dBm. Even so, the handset could still operate with a desired signal level of less than -111 dBm, which is still 6 dB below the thermal noise floor."[206] Under such extreme conditions it may not be reasonable to consider that the PCS system achieves a 14.4 kbps data rate associated with a Rate Set 2 system. Instead, the use of a 9.6 kbps data rate associated with a Rate Set 1 system appears more appropriate. The processing gain of a PCS system for Rate Set 1 is 21.2 dB.[207] These parameters result in the following link budget analysis:

Parameter	Value	Equation
Frequency	1900 MHz	F
Receiver antenna gain	-4.6 dBi	AG
PCS receiver line loss	-2 dB	LL
Received desired signal level [208]	-112 dBm/MHz	S
Processing gain	21.1 dB	PG
Minimum required S/(N+I)	6.2 dB	S/(N+I)
Maximum N+I [209]	-97.1 dBm/MHz	MaxNI = S + PG – S/(N+I)
Total noise level [210]	-99 dBm/MHz	N
Maximum UWB emission level [211]	-101.6 dBm/MHz	IR = MaxNI – N [212]
Maximum UWB emission level at the PCS handset antenna [213]	-95 dBm/MHz	I = IR –AG – LL

[205] Sprint presented measurements showing a background noise level in the C band portion of the PCS bands of around -112 dBm and in the D band portion of the PCS bands of around -111 to -114 dBm. *See* Sprint *ex parte* filing of January 30, 2002, at pg. 4-7 of the Appendix. However, these measurements were taken indoors in a single location and cannot be considered to be representative of typical operating conditions.

[206] Sprint Petition for Reconsideration, Attachment 1, at pg. 4.

[207] Even with the processing gain from a Rate Set 1 system, the signal variations due to multipath will continue to cause the operation of the PCS system to be unreliable at the signal level and noise plus interference level specified by Sprint. However, at this processing gain level and associated data rate the PCS handset will be able to accommodate the noise from another PCS handset 100 meters away or the noise from a consumer microwave oven 57 meters away.

[208] This is the signal level at the antenna terminals, not at the antenna.

[209] This is the maximum noise plus interference level that the PCS receiver can tolerate under the described parameters.

[210] This is the noise level due to the in-cell and other-cell PCS emissions combined with the PCS handset thermal noise, as specified by Sprint.

[211] This is the level of additional noise that can be accommodated at the PCS antenna terminals while still providing a S/(N+I) of 6.2 dB for the -112 dBm/MHz received desired signal with a -99 dBm/MHz noise plus interference level already imposed on the receiver.

[212] These values are not added directly in their dBm/MHz format but are added as actual power levels.

UWB emission limit	-53.3 dBm/MHz	E
Required path loss	41.7 dB	PL = E – I
Maximum separation distance	1.5 meters	20 log (D) = PL – 20log(F) + 27.56 [214]

The above calculations are based on the emission limits for GPRs, wall imaging systems, low frequency through-wall imaging systems, medical imaging systems and indoor UWB devices. Surveillance systems are permitted to place emissions in the PCS band at a level of -51.3 dBm/MHz, resulting in a increase to the maximum separation distance of 26 percent, *i.e.*, to 1.9 meters. However, we note that surveillance systems are unlikely to be in close proximity to PCS handsets, as explained under the later discussion on SDARS. Taking into account the 9 dB attenuation provided by the wall through which the signal must first pass, the new UWB public safety imaging systems being allowed in this MO&O would place emissions in the PCS band at a level as high as -50.3 dBm/MHz, resulting in an increase to the maximum separation distance of 41 percent, *i.e.*, to 2.2 meters. However, these devices will be operated under the control of a licensed public safety operator in emergency circumstances. Any equipment located within 2.2 meters of the UWB operator also would be under the control of that operator.[215] Vehicular radar systems and hand held (outdoor) UWB devices are permitted to place emissions in the PCS band at a level of -63.3 dBm, resulting in a decrease to the maximum separation distance of 68 percent, *i.e.*, to 0.5 meters.

82. The above example demonstrates that the emissions from nearby UWB devices will not cause harmful interference to PCS operation even when the background noise level and the received signal level from a PCS system are at such extremes that there is insufficient margin to accommodate naturally occurring multipath signals. However, we recognize that the petitioners may object to our application of a Rate Set 1 system. Accordingly, we are providing below a third link budget analysis that applies the parameters specified by the petitioners, including a Rate Set 2 processing gain of 19.4 dB. However, we are reducing the level of the PCS in-cell and other-cell noise. We believe than an in-cell and other-cell noise level of -100 dBm/MHz is still excessive but is more reasonable than the level presented by Sprint.[216]

Parameter	Value	Equation
Frequency	1900 MHz	F
Receiver antenna gain	-4.6 dBi	AG
PCS receiver line loss	-2 dB	LL
Desired signal level	-106 dBm/MHz	DSL
Received desired signal level	-112.6 dBm/MHz	S = DSL + AG + LL
Processing gain	19.4 dB	PG
Minimum required S/(N+I)	6.2 dB	S/(N+I)

(...continued from previous page)

[213] This is the maximum emission level that can be accommodated by the PCS handset from the UWB emitter without exceeding the maximum permitted noise plus interference level, *i.e.*, MaxNI in the above chart.

[214] This is the formula for free space path loss with F in megahertz.

[215] Without taking into account the attenuation from the building walls through which the UWB public safety imaging signals must pass, the level permitted from the imaging system is -41.3 dBm/MHz and the separation distance increases to 6 meters, a distance that still is well within the control of the public safety operator.

[216] We believe that the actual level is closer to the -106 dBm/MHz to -112 dBm/MHz shown by Sprint on pg. 11 of the Appendix to its *ex parte* submission of January 30, 2002. A lower in-cell and other-cell noise level would reduce the calculated maximum separation distance.

Maximum N+I	-99.4 dBm/MHz	MaxNI = S + PG – S/(N+I)
PCS noise level [217]	-100 dBm/MHz	PCSN
Received PCS noise level	-106.6 dBm/MHz	RPCSN = PCSN + AG + LL
Receiver thermal noise level	-106 dBm/MHz	RTN
Total noise level [218]	-103.3 dBm/MHz	N = RPCSN + RTN [219]
Maximum UWB emission level [220]	-101.7 dBm/MHz	IR = MaxNI – N [221]
Maximum UWB emission level at the PCS handset antenna	-95.5 dBm/MHz	I = IR –AG - LL
UWB emission limit	-53.3 dBm/MHz	E
Required path loss	42.2 dB	PL = E – I
Maximum separation distance	1.6 meters	20 log (D) = PL – 20log(F) + 27.56

83. While it could be argued that the -100 dBm/MHz in-cell and other-cell noise level applied above is arbitrary, we note that this noise level continues to result in the PCS system not having sufficient margin to overcome its own naturally occurring multipath interference. It is obvious that a higher PCS signal level or a lower PCS in-cell and other-cell noise level is needed for reliable operation. Either of these will result in shorter maximum separation distances between the PCS handset and a UWB emitter than that calculated in the above link budget analyses.

84. The maximum separation distances shown in the preceding paragraphs are similar to those calculated earlier for the *R&O*.[222] We do not consider these separation distances to be excessive. We also note that there are several mitigating factors that will further reduce these calculated maximum separation distances. The separation distances calculated above, as they were in the earlier staff analysis, are based on worst case conditions. In particular, this analysis includes the interference that PCS stations generate to themselves, *i.e.*, the noise produced by the in-cell and other-cell PCS emissions. This noise addition considerably increases the calculated maximum separation distances between the PCS handset and the UWB emitter. Further, the calculations assume that the UWB transmitter is pointed directly at the PCS receiver without additional losses due to mismatched antenna polarizations, head loss,[223] or attenuation from intervening objects, and that free space attenuation applies to the propagation. The calculations also assume that the UWB emitter is placing the maximum levels of emissions permitted under the rules into the PCS bands even though the UWB fundamental emission may be far removed from the PCS bands. Accordingly, we believe that the actual separation distances needed to avoid

[217] This is the noise from PCS in-cell and other-cell emissions.

[218] This is the noise level due to the in-cell and other-cell PCS emissions and other noise sources combined with the PCS handset thermal noise.

[219] These values are not added directly in their dBm/MHz format but are added as actual power levels.

[220] This is the level of additional noise that can be accommodated at the PCS antenna terminals while still providing a S/(N+I) of 6.2 dB for the -106 dBm/MHz desired signal.

[221] These values are not added directly in their dBm/MHz format but are added as actual power levels.

[222] As noted above, Sprint alleges that our staff analysis determining what limits should apply to UWB emissions in the PCS bands was not performed until May 3, 2002, approximately 2 and ½ months after adoption of the *R&O*. In actuality, these calculations were performed prior to June of 2001 and the text was drafted prior to August of 2001. The paper describing the analyses simply was not placed into the record for this proceeding until after the Commission adopted and released the *R&O*., *i.e.*, April 22, 2002.

[223] Head loss is signal blockage from the head and body of the person holding the PCS handset. As revealed in the joint Sprint PCS/TDC tests, head loss can range between 12 to 15 dB. Loss from antenna polarization can vary between 1.5 and 2.5 dB. *See* XSI comments of 5/10/01 at pg. 11.

interference to PCS handsets from UWB devices will be smaller than those calculated under theoretical worst case conditions.

85. We also continue to believe that the reception of lower desired PCS received signal levels, such as the -115.3 dBm/MHz level cited by Sprint,[224] represents extreme conditions, achievable only in a laboratory environment, as such levels do not include sufficient margin to overcome multipath interference combined with interference from other noise sources, such as the in-cell and other-cell interference from other PCS operations. While it may be possible to receive a signal level of -115.3 dBm in a laboratory environment, based on the data provided by the petitioners it may not be possible to do so in a "real world" environment. However, we also realize that the PCS desired signal levels, the PCS in-cell and other-cell noise levels, and the noise levels produced by other RF devices are not constant values but are subject to considerable fluctuation. We expect that in-band noise levels may be lower in less congested areas, allowing the use of lower received PCS signal levels. In these less congested areas, UWB transmitters are unlikely to be present in significant numbers, reducing the probability that UWB transmitters would be near PCS handsets attempting to operate with low signal reception levels. The probability of UWB systems being nearby PCS handsets is higher in congested areas where the probability of higher noise levels from various radio operations should result in higher desired PCS nominal receive signals.

86. The above interference calculations apply equally to PCS receivers used indoors or outdoors. XSI is correct in its comment that the lower emission limit specified in the rules for outdoor, handheld UWB transmitters was established not to protect PCS but to protect U.S. Government radio systems operating on both sides of the PCS spectrum. Indeed, if the emission limits were based solely on the level necessary to protect PCS operation, it appears that we could increase the limit currently applied to hand held (outdoor) and vehicular radar UWB devices. While Cingular objects to our not providing similar analyses for TDMA and GSM modulation types, we based our analysis on the specifications provided by the proponents. We note that Cingular has not provided any additional information on other types of modulations that could be employed for cellular or for PCS.

87. We disagree with Sprint that the emissions in the PCS bands are spurious emissions that may be attenuated without affecting the UWB transmission. As stated by XSI, UWB devices have a shallow emission attenuation curve such that requiring additional attenuation in the PCS band would impair performance at higher frequencies. Contrary to Sprint's assertion, we found no agreement from Time Domain to reduce the emissions in the PCS band from its equipment by an additional 15 dB. Time Domain only speculated that the requirements to reduce its emissions below the Part 15 general emission limits by 10 dB below 3100 MHz and by 34 dB below 1610 MHz would result in a natural roll-off of emissions in the PCS bands, equivalent to 20 dB below the Part 15 general emission limits.[225] However, we also recognize that, depending on the nature of the spurious emissions, this may not be a correct statement. We find no technical basis that persuades us to impose increased equipment costs on UWB manufacturers to provide additional attenuation that does not appear to be necessary to prevent harmful interference.

88. We also disagree with Sprint and AWS that UWB emission levels in the PCS bands should have been adjusted to account for a cumulative effect from multiple UWB emitters. The petitioners and commenters offer no new evidence to refute the record in the *R&O*. As explained in the *R&O*, there is no cumulative impact to PCS handsets from UWB emitters. If the potential for harmful interference extends only a few tens of meters or less, as with UWB emissions, the single closest UWB

[224] Sprint Petition for Reconsideration, Attachment 2, at pg. 6.

[225] Time Domain comments at pg. 9-10.

emitter will dominate the received signal level.[226] Systems that would be prone to receiving cumulative interference are those that employ high gain receiving antennas directed over large geographical areas and that are located where there would not be nearby UWB emitters that could dominate the received signal level. Sprint requests that a 6 dB adjustment be provided for PCS operation, as well as for indoor GPS reception, since a 6 dB cumulative impact was provided in the *R&O* for outdoor GPS reception. However, that provision for an additional 6 dB of protection for outdoor GPS protection was provided at the insistence of NTIA and DOD. This 6 dB adjustment is not applicable to the interference scenarios presented by Sprint.

89. In summary, we find the arguments of Cingular, Qualcomm and Sprint unpersuasive that there will be significant interference from UWB devices to PCS operations. With the exception of GPRs and the new public safety imaging systems, we have not permitted UWB systems to deliberately transmit in the PCS spectrum.[227] With those two exceptions, only spurious emissions from UWB devices are permitted in the PCS bands. There is no certainty that most UWB devices will even emit RF energy in the PCS bands at significant levels. Further, we conclude that the petitioners' assessments of potential interference are based on worst case scenarios where the PCS signal is at its weakest and the PCS receiver is at its minimum threshold of operation. In fact, we question whether the petitioners' approach to their analyses is representative of the risk of interference. Indeed, when the signals become weak PCS systems are designed to transfer the handsets to another cell with a stronger signal. Notwithstanding these observations, our analysis is based on what we believe are more realistic assumptions that demonstrate a potential for UWB interference to PCS operation of only a matter of meters, even under worst case conditions. We conclude that the instances of interference to PCS systems from UWB devices at such close separations will be rare and that the standards adopted adequately ensure protection against harmful interference. Nevertheless, as we have stated relative to other systems, we will closely monitor the development of UWB devices and their potential for interference and will adjust the standards if that is shown to be necessary. Thus, we find no justification to support the claims of the petitioners that the operation of UWB devices will result in harmful interference to cellular operations, to PCS operations or to E-911 applications, or that there will be increased power requirements or service disruptions to cellular or PCS operations. We also find no basis in the claims of the petitioners that additional cellular or PCS towers would need to be constructed. Accordingly, there is no reason to require additional attenuation of UWB emissions in the PCS bands.

90. *UWB Emission Levels in the Cellular Bands*. The previous discussion dealt with the potential for UWB operations to affect operation in the PCS frequency bands. While the petitioners also request that decreased UWB emissions apply to the cellular frequency bands, they did not provide any new information to support their request. While they mention potential UWB interference to the Cellular Radiotelephone Service, they offer no new technical details regarding the operation of cellular systems nor do they provide any discussion refuting the Commission's discussion in the *R&O* regarding the acceptable level of UWB emissions in the cellular radio spectrum. As in the PCS band, emissions from cellular stations and from other radio services are expected to represent the dominant interference sources and should effectively mask the low level UWB emissions. Accordingly, we find no justification to

[226] We also note the likelihood that only one UWB device would be operating in a closed system at any one time so as to reduce mutual interference. As indicated by XSI, it is unlikely that more than one UWB transmitter would be operating in close proximity to a victim receiver. Sprint earlier acknowledged that many types of UWB devices will not transmit continuously, but rather will transmit burst or packets as necessary. *See* Sprint PCS comments to the *Notice*, *supra*, at Attachment 1, pg. 1-2.

[227] While GPRs are being permitted to transmit in the PCS frequency bands, they must operate at a level not to exceed -53.3 dBm/MHz, a level 12 dB below the Part 15 general emission limits. While the public safety imaging systems also are permitted to operate in the PCS bands, these systems will be under the operational control of licensed public safety officials and there is a low probability that the operation of this equipment would be near PCS equipment, as discussed earlier in this Memorandum Opinion and Order.

amend our limits on UWB emissions in the cellular bands.

91. *Evaluation of Earlier Submitted Analyses.* Sprint complains that the Commission ignored its Telcordia model as well as its ambient noise study. The Commission reviewed and evaluated the Telcordia model in the *R&O*.[228] On the other hand, the ambient noise study from Sprint was not addressed in the *R&O*. This study was submitted by Sprint in an *ex parte* filing on January 30, 2002, over one year past the due date for comments in this proceeding.[229] Sprint's Telcordia model and the majority of its ambient noise study are encompassed in its Petition for Reconsideration and are addressed above. Sprint's measurement of noise levels in the PCS band, as shown in the Appendix to its ambient noise study, are addressed by our own recent ambient noise measurements, discussed later in this Memorandum Opinion and Order. Sprint's measurement of emission from computers, as also described in the Appendix to its ambient noise study, is flawed as Sprint did not follow the proper measurement procedures specified under 47 C.F.R. § 15.31(a)(6). We have found that the majority of RF noise emitted by computer systems is radiated from the connecting cables, yet it appears that Sprint attempted to measure the noise from a computer without adding peripheral devices or external cables and by placing the measurement antenna too close to receive emissions from the overall computer. Accordingly, upon subsequent examination of these documents we find no new evidence that would cause us to amend the UWB regulations.

92. *UWB Emission Levels in the GPS Bands*. Neither Sprint nor the commenting parties provide any technical information to support the need for additional protection to GPS reception. We note that the limits for emissions in the GPS frequency bands already are very conservative. They were based on a short separation distance of 2 meters and a UWB emission level that could result in a slight (1 dB) increase in the noise floor of the GPS receiver under very conservative assumptions. To our knowledge, no correlation has ever been made between this slight rise in the noise floor and actual GPS harmful interference. Indeed, the tests performed by NTIA, DOT and Time Domain demonstrated that GPS receivers were capable of rejecting considerably higher UWB emission levels even when the GPS received signal levels continue to be based on the satellites' end-of-life output levels and the UWB modulation types were adjusted to produce worst-case results.[230] As we have continued to demonstrate, it is extremely unlikely that UWB systems operating in compliance with the rules will cause harmful interference to the reception of cellular, PCS or GPS signals. Accordingly, we see no threat to E-911 operation from UWB devices.

93. *Send/Acknowledgement Requirements*. We disagree with Sprint that the send and acknowledgement requirements in the rules for hand held UWB transmitters should be applied to indoor transmitters and that the timing interval for acknowledgement should be decreased. The rules require a hand held UWB transmitter to cease transmission within 10 seconds unless it receives an acknowledgement from the associated receiver that its transmission is being received. An acknowledgement of reception must continue to be received by the UWB transmitter at least every 10 seconds or the UWB transmitter must cease transmitting. This provision was implemented to provide further protection to U.S. Government radio systems. Sprint requested that this requirement be extended

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228 *See R&O*, *supra*, at para. 71, 155 and 157.

229 Parties should not submit detailed technical comments disguised as *ex parte* submissions far beyond the end of the comment period, indeed almost up to the sunshine cut-off for discussions, and expect those submissions to receive a full evaluation in the text of the item.

230 The minimum GPS receiver susceptibility level measured by NTIA in its tests of noise-like UWB emissions was -108 dBm whereas the GPS susceptibility level used in the *R&O* was -117.5 dBm. In an *ex parte* filing submitted on January 11, 2002, Qualcomm provided test data demonstrating that there was no loss in the number of acquired GPS satellites and no degradation to position accuracy as long as the UWB emissions at the antenna port of an assisted GPS receiver incorporated in a PCS handset did not exceed a level of about -108 dBm/2 MHz. This level is comparable to the test data obtained by NTIA and by DOT.

to include indoor UWB systems and to change the 10 second period to 3 or 5 seconds. However, Sprint provides no reasons as to why such changes should be required. There already exists a requirement for indoor devices used as communications systems to transmit only when sending information to an associated receiver.[231] No information has been provided by Sprint as to why the existing rule is not sufficient.

94. *Restrictions Applied to Ensure Indoor-only Operation*. We disagree with Cingular that there is a need to change our regulations restricting certain UWB devices to indoor operation. The rules currently require indoor UWB devices, by the nature of their design, to be capable of operation only indoors, adding that the necessity to operate with a fixed indoor infrastructure, such as a requirement to operate using the AC power lines, may be sufficient to demonstrate compliance with this requirement.[232] Cingular expresses its belief that there is no correlation between UWB devices requiring AC power and in-building use since AC power can be obtained through generators and through long extension cords. However, the reason for prohibiting fixed outdoor UWB operation was to reduce the ability to establish wide-coverage, cellular-type systems. We believe it unlikely that complex outdoor cellular-type UWB operations would be established with equipment using long extension cords or generators to operate. Even so, the requirement to operate from the AC power lines is not by itself evidence that the equipment is designed for indoor-only operation. The equipment still must, by the nature of its design, be capable only of indoor operation.

95. *Imaging Systems/Coordination*. As demonstrated above, the petitioners' claims of harmful interference from UWB emissions are unfounded. Accordingly, there is no justification for raising the frequency range in which UWB transmissions are permitted to operate; for requiring imaging systems to be capable of functioning only when they are in direct contact with a wall surface; for requiring imaging systems to use automatic power control; or for placing additional restrictions on who may operate the equipment. Further, we find no justification requiring coordination of the location of UWB imaging systems with cellular telephone service providers, as there is no reason to believe that these products, operating in compliance with the rules, will cause harmful interference to such services. With regard to Sprint's assertion that surveillance systems are not imaging systems and so should be classified as indoor or hand held devices, we recognize that surveillance systems may not necessarily be designed to resolve an image of a detected object. However, surveillance systems are radar devices that function similar to other imaging systems. It was for this reason that they were classified as imaging systems. Indeed, vehicular radars could have been classified in a similar manner; the Commission chose not to do so as vehicular radars are consumer products and are not subject to coordination requirements. Regardless, the classification of surveillance systems as UWB imaging devices does not affect their interference potential. The interference potential of an RF device is governed by the technical standards under which it operates. There is no basis to support any claim that surveillance systems operating at the emission levels specified in our rules would cause harmful interference to other radio operations.[233] Consequently, we see no reason to change the classification for this product or the standards under which it operates.

96. *Need for Additional Test Data*. Qualcomm states that the Commission should have

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231 47 C.F.R. § 15.517(a)(5).

232 47 C.F.R. § 15.517(a)(1).

233 In particular, we believe, as cited by Time Domain in response to the petition from Sirius and XM, that surveillance systems would be used to detect the motion of persons or objects within a protected area and would not be placed where there is frequent and allowable motion of objects, persons, or animals, such as along streets, as this would obviate the utility of the system. Time Domain comments at pg. 13-14. Thus, surveillance systems would be used to protect areas that are "off limits," and the probable location would be well behind a fence or other obstacle far from a roadway or from general pedestrian areas.

established standards for UWB emissions in the PCS bands based on test data. Sprint requests that the Commission require each UWB equipment developer to make multiple samples of their products available to industry for interference evaluations. AWS wants all interested parties to participate in setting up tests using real UWB devices. We find no need to require the submission of additional test data in this proceeding before UWB systems can begin operation. There have been considerable analyses throughout this proceeding on every possible aspect of interference under the worst receive conditions imaginable. Tests already have been performed, not using real UWB devices since compliant UWB devices were not yet available but using generated signals that range from a noise-type emission to modulation types that have the highest probability of causing interference. We see no need to further delay this proceeding by providing additional testing. Once equipment is on the market, interested parties may obtain and test whatever UWB samples they might desire. However, we expect that such tests will demonstrate that UWB devices have a lower interference potential than what has been calculated. The calculations are based on the premise that UWB devices operate at the maximum permitted emission limits across the entire radio spectrum. In reality, this is not feasible as this would require the UWB transmitter to consume such tremendous amounts of power that battery operation would not be possible. If the UWB transmitter was assumed to emit a line spectrum, earlier evaluations adjusted the frequency of the spectral line(s) such that it produced the maximum interference effect on a victim receiver, even if the frequency of the victim receiver was changing with time, such as occurs with the signal from a GPS satellite. Other examples of how the potential for interference has been maximized are cited throughout this Memorandum Opinion and Order. An interference test based on actual UWB production units will not encounter all of these worst case conditions at the same time.

97. *Conclusion*. We find no new information in the Cingular, Qualcomm, and Sprint petitions or in the comments that would persuade us to amend or otherwise reverse the decisions made in the *R&O*. Specifically, we find no basis or justification in the proponents' claims that exclusive licensing in the PCS spectrum prohibits the operation of Part 15 devices; that stricter limits are needed for emissions from UWB devices that fall within the cellular, PCS or GPS bands; that we must require UWB manufacturers to provide samples to industry for testing; that we must amend the language regarding the requirement for indoor devices, by the nature of their design, to be capable of operation only indoors; that we need to modify the send/acknowledgement requirements for UWB communication systems; or that we should tighten the rules for imaging systems. We further find no basis in the petitioners' claims that the Commission did not adequately consider the various tests or analyses or that the decisions in the *R&O* were arbitrary or capricious. Accordingly, we are denying the Petitions for Reconsideration from Cingular, Qualcomm, and Sprint.

2. UWB emissions in the SDARS frequency bands

98. The Satellite Digital Audio Radio Service (SDARS) operates in the frequency bands 2320-2332.5 MHz and 2332.5-2345 MHz. Sirius, which operates under the name Satellite CD Radio Inc., uses the lower band, and XM uses the upper band. Through-wall imaging systems and surveillance systems, the only UWB devices permitted to operate in the SDARS bands, must not exceed an emission level of -41.3 dBm/MHz in the SDARS spectrum. All other UWB devices are required to attenuate any emissions that appear in the SDARS bands, as follows: 1) GPRs, wall imaging systems, low frequency through-wall imaging systems, medical imaging systems, and indoor UWB devices must attenuate emissions in the SDARS bands to at least -51.3 dBm/MHz; 2) vehicular radar systems and hand held UWB devices must attenuate their emissions in the SDARS bands to at least -61.3 dBm/MHz; and 3) the new public safety imaging systems must attenuate their emissions in the SDARS bands to at least -41.3 dBm/MHz.

99. Petition. Sirius and XM filed a Joint Petition for Reconsideration stating that the Commission disregarded evidence that highly sensitive satellite radio receivers will operate in close

proximity to UWB communications and surveillance devices.[234] Indicating that SDARS receivers operate near the noise floor with a link margin just sufficient to protect against outages from blockage, multipath fading and foliage attenuation, they request that we reduce the permitted emission limit in the SDARS frequency band from UWB devices to no greater than 8.6 uV/m, as measured at 3 meters within a 1 MHz bandwidth,[235] and that compliance with this limit be demonstrated based on free space attenuation of the emissions from an aggregate of multiple co-polarized UWB devices.[236]

100. Sirius and XM argue that the -51.3 dBm limit adopted for emissions in the DARS band from indoor UWB devices is too great and that the Commission should have adopted the 8.6 uV/m limit they requested.[237] They state that the Commission did not explain why it did not adopt the 5.8 uV/m limit[238] it applied to Wireless Communication Service (WCS) systems and that is applied through coordination agreements with Mexico and Canada. Sirius and XM believe that the rules adopted for hand held UWB devices will permit dense, temporary, semi-permanent or mobile communications networks and that aggregate emissions from these networks will cause serious interference to SDARS reception. They argue that the Commission incorrectly assumed an antenna polarization mismatch of 3 dB and a receiver noise temperature of 360º K. They state that the 3 dB antenna cross-polarization factor should be eliminated because the Commission did not apply this in its analysis of the emissions for UWB devices in the GPS bands, noting that the GPS systems also use a circularly polarized receiving antenna.[239] They also state that a noise temperature of 158º K should be employed.[240] Based on the elimination of the antenna cross-polarization and the decrease in the receiver noise floor, Sirius and XM recalculate the minimum separation distances to be 55 meters for surveillance systems, 17 meters for indoor UWB devices, and 5 meters for hand held devices.[241] Sirius and XM state that any limit that allows interference at distances greater then 3 meters is unreasonable, arguing that UWB devices are likely to be in close proximity to SDARS receivers.

101. The petitioners also argue that the Commission failed to satisfy the Administrative Procedure Act by failing to provide a reasoned basis for its actions, consider all of the evidence presented to it, and articulate a rational connection between the presented facts and its decision.[242] Sirius and XM further contend that the *R&O* contains faulty assumptions such as: exaggerating the available link margin and assuming that there always will be a terrestrial repeater nearby; assuming that SDARS receivers and UWB communications and surveillance devices will operate no closer than 8.8 meters and that there will never be more than one UWB device at a time in the vicinity; failing to account for consumers listening to SDARS in their homes; assuming that UWB manufacturers will not build transmitters that operate at the maximum limit permitted by the rules; assuming that what the Commission referenced as "transient" interference is irrelevant when it actually is highly disruptive; ignoring previous Commission national and international actions limiting emissions in the SDARS bands;[243] and under-estimating the minimum

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234 Sirius and XM Joint Petition for Partial Reconsideration at pg. ii.

235 This is equivalent to an EIRP of -76.5 dBm/MHz.

236 *Id.* at pg. 2.

237 *Id.* at pg. 6. Sirius and XM requested this limit in an *ex parte* filing on February 7, 2002.

238 This is equivalent to an EIRP of -80 dBm/MHz, *i.e.*, 0.000,000,000,010 watts/MHz.

239 As stated in paragraph 2 of the *R&O*, *supra*, parties should not consider the analyses and technical standards discussed in the *R&O* as a technical basis for determining or revising standards

240 Sirius and XM Joint Petition for Partial Reconsideration, Technical Appendix at pg. 2.

241 Sirius and XM Joint Petition for Partial Reconsideration at pg. 11.

242 *Id.* at pg. 4-5.

243 *Id.* at pg. ii.

required separation of UWB devices and SDARS receivers, concluding that 8.8 meters is sufficient.[244] They object to the user of the SDARS receiver having to keep the receiver removed from UWB devices, stating that the SDARS user will not realize that interference is being caused as the signal will simply cease being received resulting in the user blaming the equipment manufacturer or service provider.[245]

102. Sirius and XM state that UWB vehicular radar systems are unlikely to cause interference to DARS yet request that the Commission lower the limit for emissions in the DARS bands from UWB vehicular radars to 8.6 uV/m.[246] Sirius and XM believe that devices other than vehicle radars would be closer to SDARS receivers, such as a hand held device used by a passenger in the car. They add that a hand held device in a car, a surveillance device nearby the car, or an indoor UWB device a few feet from an SDARS receiver will cause harmful interference under the adopted limits. Sirius and XM also object to the Commission considering their use of terrestrial repeaters to supplement reception in major metropolitan areas, stating that this impermissibly shifts the burden of mitigating interference to the operator of a licensed system.[247] They add that their systems rely on the reception of the satellite signals, not signals form the terrestrial stations, in 99 percent of the U.S. land mass. Sirius and XM also object to any short term, transient interference, such as when a vehicle containing an SDARS passes by a UWB surveillance system, and specifically cite the continuous interference that would be caused to a SDARS receiver located in a car passing along a perimeter that is secured by a long series of surveillance systems.[248] They also argue that the Commission was arbitrary and capricious by failing to provide an additional margin of protection from aggregate interference from multiple UWB devices and by failing to explain why such an analysis was not performed.[249] Sirius and XM, contending that hand held, indoor, and surveillance UWB systems are likely to be within close proximity of SDARS receivers, cite NTIA Special Pub. 01-43 at pg. x as a demonstration that there is an aggregate interference problem. Sirius and XM's petition also includes a technical appendix within which they re-analyze the interference separation distance after eliminating the 3 dB antenna polarization mismatch and basing the thermal noise floor of the receiver on a temperature of 158º K.[250] They indicate that a receiver noise temperature of 290º K may be appropriate when the DARS receiver is located in an urban environment, but a temperature of 158º K is suitable when the DARS receiver is located in an environment suitable for satellite reception.

103. Comments. Time Domain submits that emissions from UWB transmitters are required to be attenuated by 34 dB as they go from 3.1 GHz to 1.6 GHz, and that this will result in lower emission levels in the SDARS bands than what is specified in the rules.[251] Time Domain believes that UWB emissions effectively would be attenuated by about 30 dB below the Part 15 general emission limits within the SDARS frequency bands.[252] It adds that emissions from hand held UWB devices, which are expected to be nearest to SDARS receivers, must not exceed -61 dBm in the 1.99-3.1 GHz band under the rules and that these factors correlate with the -63 dBm that the Commission found to be appropriate for portable WCS devices operating under 250 mW.[253] Time Domain states that the Commission's intention

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244 *Id.* at pg. 10.

245 *Id.* at pg. 12-13.

246 *Id.* at pg. 16-18 and at footnote 44.

247 *Id.* at pg. 19-20.

248 *Id.* at pg. 20-22.

249 *Id.* at pg. 22-23.

250 *Id.* at technical appendix, pg. 1-3.

251 Time Domain comments at pg. iii.

252 *Id.* at pg. 14-17.

253 *Id.* at pg. iii and 15-16. 47 C.F.R. § 27.53(a)(9).

in determining emission limits for WCS was to limit the interference to a reasonable level, not to provide a pure, interference-free environment.[254] Accordingly, it believes that SDARS operators also should not expect now to have an interference free environment and that it is unrealistic of them to expect the Commission to suddenly recognize "transient" interference as a form of interference the SDARS service must be protected against.

104. Time Domain adds that the SDARS link budget, among other factors, provides for blockage, fading and foliage attenuation, and that there is a zero probability of all of these occurring at the same time, so that it was entirely appropriate for the Commission to conclude that the SDARS link budget has an excessive margin.[255] With regard to terrestrial repeaters, Time Domain states that the issue is not what percentage of the U.S. has terrestrial coverage but what percentage of the population will be served by terrestrial augmentation and believes that terrestrial systems would be located around cities, the environment where UWB devices will be found and where the satellite signal would be subject to blockage, fading and foliage attenuation.[256] With regard to UWB surveillance systems, Time Domain states that these systems would be used to detect the motion of persons or objects within a protected area and would not be placed where there is frequent and allowable motion of objects, persons, or animals, such as along streets, as this would destroy the utility of the system.[257] Rather, surveillance systems would be used to protect areas that are "off limits," and the probable location would be well behind a fence or other obstacle much farther from a roadway than 8.8 meters. With regard to the petitioners' claim that the Commission failed to consider SDARS receivers used in homes, Time Domain notes that in the *R&O* the Commission referenced SDARS antennas mounted on building roofs or the sides of buildings and added that SDARS receivers may function with the antenna mounted in the home, but it would do so only because of the additional signal from a terrestrial repeater.[258]

105. SARA opposes Sirius and XM's request to tighten the limit in the SDARS bands on emissions from vehicular radars.[259] It notes the petitioners' statement that vehicle radar was unlikely to interfere with SDARS. SARA adds that it is virtually impossible to design a functioning antenna at 24 GHz that also radiates with sufficient energy at any frequency below about 17 GHz and that all emissions below 14.125 GHz would be considered spurious emissions.

106. XSI, in addressing the petitioners' argument that the Commission incorrectly applied a 3 dB factor for antenna mismatch, notes that circularly polarized antennas that operate correctly over the entire UWB spectrum would be difficult or impossible to design and would offer no advantages over linear polarization.[260] It adds that while the polarization of the UWB antenna may be "unknown," it is almost certainly not circular.[261] XSI also states that the 360º K receiver noise temperature employed by the Commission in its analysis is identical to the value for this parameter provided earlier by XM, adding that the numbers now offered by the SDARS proponents make sense only if the SDARS receivers are in orbit or use a pencil-beam antenna, unlike the non-directional antennas actually installed on such

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[254] *Id.* at pg. 16. *See*, also, *Memorandum Opinion and Order* in WT Docket No. 96-228, 12 FCC Rcd 3977 (1997) at para. 25.

[255] Time Domain comments at pg. 12.

[256] *Id.* at pg. 12-13.

[257] *Id.* at pg. 13-14.

[258] *Id*. at pg. 14; *R&O*, *supra*, at para. 169.

[259] SARA comments at pg. 4-7.

[260] XSI comments at pg. 22.

[261] *Id.* at pg. iv, technical appendix.

receivers.[262] XSI believes two statements by the SDARS proponents are inconsistent: the SDARS signal is so weak as to require extraordinary protection from UWB, and the SDARS signal functions well indoors despite about 9 dB of building loss.[263] XSI believes that indoor SDARS reception requires either a nearby terrestrial repeater or the use of an outdoor antenna, as the SDARS proponents' own numbers make it unlikely that an indoor antenna can achieve reliable reception from the satellite.

107. XSI also submits that the one percent of the SDARS service areas that has repeater coverage accounts for a large fraction of the population served. It also agrees with Time Domain that the emissions from the UWB emitters will be lower in the SDARS bands than the levels required under the rules due to the roll-off of the emissions below 3.1 GHz to comply with the limit transitions at 1.99 GHz and at 1.6 GHz.[264] XSI argues that the SDARS proponents attempt to minimize the potential effect of other, non-UWB sources of interference on SDARS service, noting that Part 27 WCS stations must reduce their emissions that appear in the SDARS bands to -80 dBm, but fail to point out that certain fixed, land, and radiolocation stations in the WCS service are allowed to have emissions in the SDARS bands at -50 dBm, 1.3 dB more than allowed for indoor UWB devices.[265] Further, it says that the number cited by Sirius and XM for terrestrial stations at the U.S.-Mexican border of -154 dBW/m^2/4 kHz is the limit that U.S. stations must meet, adding that the requirements for Mexican stations, depending on frequency, are -150 and -145.5 dBW/m^2/4 kHz for terrestrial stations and -130.5 dBW/m^2/4 kHz for satellite stations.[266] XSI adds that the Amateur Radio Service has bands on both sides of SDARS with no specific emission limits and that SDARS is adjacent to the 2400 MHz ISM band which has a limit equivalent to 2500 uV/m at 3 meters.[267] It further adds that measurements made by NTIA on microwave ovens at an apartment complex found emission levels radiated in the SDARS bands of -80 to -55 dBm at distances 3 meters from the ovens in the same room, -100 to -86 dBm in adjacent apartments, and -90 to -77 dBm at the exterior of the complex, compared to the -101.6 dBm expected from a UWB emitter at only 3 meters away. XSI states that the majority of man-made noise in the SDARS bands is assumed to be from ignition sources and that the proximity of ignition systems to a SDARS antenna in a mobile environment may create even greater problems than UWB emissions.

108. USGPSIC supports the petitioners' contention that aggregate emissions from widely deployed UWB devices will pose an unacceptable risk of harmful interference.[268] If also believes that the Commission's statement in the *R&O* that a UWB device could be moved a short distance away impermissibly shifts the burden of resolving the interference to the operator of the licensed system.[269] XSI replies that UWB emissions add in principle but the levels fall off so rapidly with distance that there

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262 *Id.* at pg. 22 and v, technical appendix. XM notes that the Commission's analysis was based on -110 dBm receiver noise floor supplied by XM Radio based on the KTB for a 2 MHz bandwidth and a noise figure of 1.2 dB. XSI adds that this is equivalent to a noise temperature of 70º K and that the 158º K mentioned in the petition is a better match to the Sirius receiver as it is equivalent to a noise figure of 1.85 dB. Thus, XSI indicates that the "correction" to the Commission's calculations, assuming the SDARS receiver is located on a barren mountaintop on a -40º day, is not 3.6 dB but should be minus 0.5 dB for the noise temperature provided.

263 XSI comments at pg. 23 and at pg. vi-vii, technical appendix.

264 *Id.* at pg. v, technical appendix.

265 *Id*.

266 A level of -130.5 dBW/m^2/4 kHz is equivalent to -106.5 dBW/m^2/MHz or 92 uV/m.

267 XSI comments at pg. vi, technical appendix.

268 USGPSIC comments at pg. 2 and 20.

269 *Id.* at pg. 19.

is little signal that can contribute to an additive effect.[270]

109. In their reply comments, Sirius and XM state that the rules do not require surveillance systems to be used in protected areas and that at least 55 meters of separation is necessary to avoid interference to SDARS.[271] Sirius and XM also argue that the Commission's statement in establishing the WCS rules that coordination between SDARS and WCS involved limiting the potential for interference to a reasonable level makes sense only in the context of coordination between licensed services where the Commission must strike a balance between protecting each service and enabling multiple services.[272] Sirius and XM also object to Time Domain's contention that the Commission used specific technical information to analyze the risk of SDARS interference, stating that the Commission's cursory discussion in the *R&O* of UWB interference based the separation distance not on a specific UWB device but on some undefined UWB signal and did not apply the appropriate technical data for SDARS receivers.[273] In response to the claim from Time Domain that low power portable WCS devices are permitted to operate at an emission limit in the SDARS bands of -63 dBm, Sirius and XM note that operation at this higher emission limit be permitted under Part 27 of the Commission's rules only under very limited conditions that were specifically adopted to provide protection to SDARS receivers and that no comparable operating limitations were adopted or considered for UWB devices.[274] Sirius and XM add that the link margin used for SDARS is reasonable and is designed in keeping with standard satellite system design;[275] that DARS systems can operate indoors without outside antennas even in areas unserved by terrestrial repeaters;[276] that there is no basis for assuming that UWB antennas will be linearly polarized: that SDARS uses both linearly and circularly polarized antennas;[277] that the noise temperature of the SDARS receiver could vary from 158º K to 290º K and the Commission erred in using 360º K;[278] and that SDARS systems are designed with the expectation that some interference will be inevitable from all sources, but not at the level adopted for UWB devices.[279]

110. Discussion. We continue to disagree with the claims of Sirius and XM that additional attenuation is required for UWB emissions falling within the SDARS frequency bands of 2320-2345 MHz. We also find no merit in Sirius and XM's argument that the Commission failed to satisfy the Administrative Procedure Act by failing to provide a reasoned basis for its actions, failing to consider all of the evidence before it, and failing to articulate a rational connection between the presented facts and its decision. The Commission did, in fact, provide a reasoned basis for its UWB decisions affecting SDARS issues, with consideration of the full record and articulation of its treatment of the facts, as evidenced by the analysis provided in paragraphs 168-169 of the *R&O*. The Commission simply did not agree with the claims of the petitioners. As shown in paragraph 169 of the *R&O*, the maximum separation distance for a UWB system emitting at 10 dB below the Part 15 general emission limits, *e.g.*, the limit applied to low frequency imaging systems, high frequency imaging systems, and indoor UWB

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270 XSI reply comments at pg. 6.

271 Sirius and XM reply comments at pg. 3-4.

272 *Id.* at pg. 5.

273 *Id.* at pg. 5-6.

274 *Id.* at pg. 6-7.

275 *Id.* at pg. 7.

276 *Id.* at pg. 7-8.

277 *Id.* at pg. 8-9.

278 *Id.* at pg. 9.

279 *Id.* at pg. 9.

devices, is 8.8 meters.[280] Examples also were provided as to why this calculated maximum separation distance is likely to be lower and why vehicular radar systems, which would operate in close proximity to the predominantly mobile SDARS receivers, would pose an even lower threat of causing harmful interference.

111. Sirius and XM take exception to two of the criteria the Commission employed in its analysis to determine the emission limits for UWB devices in the SDARS bands.[281] Specifically, the petitioners argue against the Commission's use of a 3 dB antenna cross polarization effect and its calculation of the thermal noise floor of the receiver. We note that the values used in the Commission's calculations are those values that were provided by the petitioners in their comments to the *Notice*.

112. As stated by the petitioners, SDARS satellite transmissions use circular polarization and the SDARS terrestrial repeaters use linear polarization.[282] As the greatest potential for harmful interference is to reception from the satellite, it is correct to base our analysis on the SDARS use of circular polarization. Further, as indicated by XSI, it is infeasible to design a UWB antenna that covers sufficient bandwidth and employs circular polarization. We also note that the petitioners stated only that the Commission should not have applied the cross polarization correction to SDARS since it did not apply this correction factor to GPS reception. This is not a sufficient basis on which to justify excluding this effect. With regard to calculations in the *R&O* for GPS potential interference, the application of a cross polarization effect was eliminated at the request of NTIA. However, this does not mean that we should not apply an antenna polarization correction in the analysis of UWB effects to SDARS reception. Consequently, the use of the 3 dB cross polarization loss is appropriate.

113. With regard to the thermal noise of SDARS receivers, the petitioners base their calculations on the use of narrow-beam antennas pointed at the satellites rather than on the omnidirectional antennas employed by SDARS receivers. The use of omnidirectional antennas, especially in urban environments where there is the greatest potential to encounter a nearby UWB emitter, justifies basing the thermal background noise level on a temperature of 290º K. This results in a thermal noise floor of -114 dBm/MHz. The noise figure of the receiver employed by XM, based on it earlier comments, is 1.2 dB resulting in a receiver noise floor of -112.8 dBm/MHz or -109 dBm over the 2 MHz bandwidth of the XM receiver.[283] Based on the receiver noise temperatures submitted by the petitioners and the comments of XSI, it appears that the noise figure for the Sirius SDARS receiver is 1.85 dB, resulting in a receiver thermal noise floor of -112.8 dBm/MHz.[284]

114. Requiring the signal from the UWB device not to exceed the lower noise floor of -112.8 dBm/MHz and applying the 3 dB antenna cross polarization results in the same maximum separation distances that were specified in the *R&O*. These maximum separation distances are 2.7 meters for outdoor hand held UWB devices and vehicular radars, 6.8 meters for through-wall imaging systems operating below 960 MHz, 8.6 meters for GPRs, wall imaging systems, medical imaging systems, and

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280 Vehicular radar systems and outdoor (handheld) UWB devices are required to operate at a lower emission level in the SDARS band and would have a lower maximum separation distance.

281 *See R&O*, *supra*, at para. 168-169.

282 Sirius and XM Joint Petition for Reconsideration, Technical Appendix, at pg. 1.

283 While the Commission did not reference a noise temperature of 360º K, as claimed by the petitioners, the application of a 1.2 dB noise figure to a noise temperature of 290º K results in an apparent noise temperature of 380.3º K. We believe that the petitioners derived their value of 360º K based on our rounded-off noise floor of -113 dBm/MHz.

284 Sirius has not supplied information on the parameters of its receivers, but it did indicate that 2 dB was a typical SDARS receiver noise figure in its comments of April 25, 2001, at pg. 3.

indoor devices, 9.7 meters for the new public safety imaging system,[285] and 27 meters for surveillance systems.[286] Upon recalculating these values, we believe that two additional points should be addressed. First, the gain of the SDARS antenna is 3 dBi gain in the direction of the satellite while it is only 0 dBi in the horizontal direction, *i.e.*, the direction of the UWB emitter.[287] Thus, 3 dB of additional signal rejection should be applied to the UWB emissions. Second, the calculations in the *R&O* were based on the emission from the UWB device not exceed the thermal noise floor of the SDARS receiver. We believe that these calculations should be redone employing a UWB signal level 6 dB below the SDARS receiver noise floor. Using these additional parameters, the following maximum separation distances are obtained: 3.8 meters for outdoor hand held UWB devices and vehicular radars; 9.7 meters for through-wall imaging systems operating below 960 MHz; 12 meters for GPRs, wall imaging systems, medical imaging systems, and indoor devices; 13.6 meters for the new public safety imaging system; and 38.5 meters for surveillance systems.

115. While some of the above calculated maximum separation distances may appear to be excessive, we note that they are based on worst case conditions. It is likely that there would be additional attenuation of the UWB emissions due to the presence of intervening objects, including the head, hands or body of the person using the UWB transmitter, along with misalignment of the UWB transmitting antenna and the SDARS receiving antenna. Further, these separation distances are based on the distance necessary for the UWB emission not to exceed 6 dB below the thermal noise floor of the SDARS receiver. It is likely that the signal from the SDARS satellite would be more than 4 dB above this thermal noise floor.[288] As indicated in the comments, the SDARS link budget provides for blockage, fading and foliage attenuation, which will not occur at all times. Accordingly, it is likely that the needed separation distances would be considerably shorter than those calculated. There are additional factors that will further shorten these separation distances, as detailed below.

116. The largest calculated maximum separate distance of 38.5 meters, and the correspondingly greatest perceived threat of harmful interference, is that of surveillance systems. However, we do not believe that surveillance systems will present an unacceptable risk of harmful interference to SDARS reception. Surveillance systems, as described by Time Domain, would be used to detect the motion of persons or objects within a protected area and would not be placed where there is frequent and allowable motion of objects, persons, or animals, such as along streets, as this would destroy the utility of the system. Thus, surveillance systems would be used to protect areas that are "off limits," and the probable location would be well behind a fence or other obstacle far from a roadway or from general pedestrian areas. Further, it is likely that the area in which an outside surveillance system is employed would be clear of obstructions, enabling visual observation as well as electronic means. In this case, there would be no blockage or foliage to reduce the SDARS link budget. Based on this, we believe the probability generally is quite low that persons using SDARS receivers would come near enough to a UWB surveillance system to experience interference problems.

117. After surveillance systems, the new UWB public safety imaging systems being allowed

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285 This distance is based on 9 dB of attenuation being provided by the wall through which the imaging signal is directed. If the wall attenuation is not considered, the separation distance of 27 meters is the same as that applied to surveillance systems.

286 The calculations in the *R&O* rounded off the receiver noise floor to -113 dBm/MHz, resulting in slightly larger separation distances.

287 While it is possible that a UWB device could be at a higher elevation, it is unlikely that this would occur unless the UWB device was inside of a building while the SDARS receiver was outside. This would result in 9 dB of average building attenuation and would also make it likely that the SDARS receiver and the UWB device were separated by a distance on the order of 10's of meters.

288 XM in its earlier comments indicated that a 3 dB S/N is required for SDARS reception.

in this MO&O result in the next largest calculated maximum separation distance, 13.6 meters. We do not believe that these devices constitute a threat of harmful interference to SDARS reception. UWB public safety imaging systems would be controlled by a licensed public safety operator and would be used in emergency circumstances where it is highly unlikely that the general public would be allowed to be in the immediate vicinity. Moreover, operation of such equipment generally will be only on a short term basis at the sites of emergency incidents.

118. For GPRs, wall imaging systems, medical imaging systems, and indoor-only devices, we calculated a maximum separation of 12 meters. For through-wall imaging systems operating below 960 MHz we calculate a maximum separation distance of 9.7 meters. Most of the energy from these UWB devices will be absorbed by the material through which they are transmitting or by surrounding walls or terrain. Wall imaging systems are employed in areas, such as bridge inspections, mine wall inspections and building ceiling inspections, where some blockage of the signal occurs before it could be received by a SDARS receiver. GPRs operate so low to the ground that their signal dissipates rapidly with distance.[289] Medical imaging systems and indoor-only UWB systems both would be used indoors. We continue to believe, as stated in the *R&O*, that SDARS antennas used for satellite reception will be mounted principally outside rather than employed indoors. The additional building attenuation of emissions from indoor UWB devices will further protect SDARS receivers. With regard to the petitioners' claim that SDARS antennas may be employed indoors for the reception of satellite signals, we agree with XSI that the claims of the petitioners are inconsistent. If SDARS systems are capable of being used in areas not served by terrestrial repeaters with the antenna placed indoors, as indicated by the petitioners, a higher link budget would have to exist to overcome building attenuation and this would obviate the need for protection at the low emission limits the petitioners claim are necessary to avoid interference.

119. Finally, hand held UWB devices and vehicular radars appear to need a maximum separation distance of 3.8 meters from the SDARS receiver. We do not consider this separation requirement to be excessive. While it is possible that a person would operate a hand held UWB device in a vehicle at the same time as receiving SDARS signals, it remains unlikely that interference would occur[290] since the emissions from hand held devices are required to be attenuated to -51.3 dBm at the point where the emission rolls off to 3.1 GHz. Because of the sinusoidal shape of the UWB emission, signals will be further attenuated at the frequencies of the SDARS band. Time Domain believes that this attenuation will result in the emissions in the SDARS bands from hand held devices being about 30 dB below the Part 15 general emission limits. Even if the amount of attenuation is not as great as that claimed by Time Domain, we believe that the maximum separation distance needed to protect SDARS reception would be considerably less than the calculated 3.8 meters. Similarly, because vehicular radars operate above 22 GHz there will not be any intentional emissions in the SDARS bands from vehicular radars. Any emissions appearing in the SDARS bands will consist solely of spurious emissions. Because the limits applied to UWB devices are lower than those applied to other Part 15 devices, there is a lower potential for vehicular radar systems to cause interference to SDARS reception than there is from personal computers and other Part 15 devices. As noted by the petitioners themselves, UWB vehicular radar systems are unlikely to cause interference to SDARS. We also believe that the emissions in the

[289] The primary emissions from GPRs are radiated into, and absorbed by, the ground. As emission measurements are made with GPRs placed over an absorptive material, the full levels of these emissions are not measured.

[290] In this specific instance, the operator of the hand held UWB device would be causing interference to his own SDARS reception, similar to the interference a consumer would receive when attempting to operate a 2450 MHz cordless telephone and a microwave oven in close proximity. The Commission generally does not attempt to protect individuals from causing interference to their own unlicensed operations due to the severe shielding and other equipment design constraints that this would entail and the high cost of consumer electronics that would result.

SDARS bands from UWB devices other than the new public safety imaging systems and surveillance systems will appear to be spurious emissions as these emissions should be sufficiently removed from the fundamental emission which must be located below 960 MHz or above 3.1 GHz.

120. We also do not agree with the petitioners that there is a need for additional attenuation of UWB emissions to protect SDARS receivers from a cumulative or aggregate impact due to emissions from multiple UWB devices. As discussed in the *R&O*, we have found that no such cumulative impact will occur.[291] Rather, the emissions from the nearest UWB emitter will dominate those from any other UWB devices in the area. Further, it is unlikely that multiple UWB devices would be operating in the same area at the same time due to the interference they would generate to each other's operation. The petitioners' argument that the Commission failed to explain why it did not perform an analysis of aggregate interference is simply incorrect. In this regard, the Commission noted NTIA's earlier study of emissions from multiple UWB devices along with XSI's demonstration that a single nearby emitter would dominate the aggregate impact.[292]

121. Finally, we believe that radio frequency emissions from other sources will dominate the RF background noise level, further shortening the needed separation distances between UWB devices and SDARS receivers. As demonstrated by XSI, the levels of emissions generated in the SDARS bands by microwave ovens, based on NTIA's earlier study,[293] may be higher than those produced by UWB devices. We also note that the fifth harmonic of Part 90 land mobile and Part 95 personal radio transmitters operating in the 464-469 MHz band will appear in the SDARS band as will the third harmonics of TV transmitters and the new public safety and commercial transmitters operating on TV channels 64-65 (770-782 MHz) and the second harmonics of aeronautical radionavigation systems operating in the 1160-1172.5 MHz band. In addition, Amateur Radio Service transmitters operate in bands adjacent to the SDARS frequencies without limits on the amount of spurious emission that may be radiated. The spurious emissions from these multiple RF sources are many orders of magnitude higher than the emission levels permitted from UWB devices and will tend to mask the emissions from UWB devices.

122. In response to the petitioners question as to why the Commission did not consider their request to employ a limit of 8.6 uV/m, as measured at 3 meters, we note that this technical request was submitted as an *ex parte* filing on February 7, 2002, over one year after the end of the comment period in this proceeding and only days prior to the Commission's final deliberations. Nevertheless, we have found that the limit requested by the petitioners is not needed to prevent harmful interference from UWB devices to SDARS reception. We also note that Sirius and XM have withdrawn their petition requesting the implementation of this emission limit for all Part 15 and 18 consumer products.[294]

123. Based on the above analyses, we find no basis to require that the emissions from UWB devices be reduced to levels lower than what were adopted in the *R&O*. Accordingly, the Petition for Partial Reconsideration filed jointly by Sirius and XM is denied.

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[291] *See R&O*, *supra*, at para. 233-234.

[292] *See R&O*, *supra*, at para. 230. *See*, also, NTIA Special Publication 01-43, *Assessment of Compatibility Between Ultrawideband Devices and Selected Federal Systems*, at pg. 5-1 through 5-34, and XSI response of July 5, 2001, *Response to U.S. GPS Industry Council ex parte Filing of 21 June 2001*, at pg. 3-4 and 5-7.

[293] NTIA Technical Memorandum 92-154 and NTIA 94-303-1, as cited by XSI in its comments, technical appendix, pg. vi.

[294] See letter of May 2, 2002, from David Leive of Latham & Watkins, Counsel for Sirius Satellite Radio Inc., and from Robert Briskman, Technical Executive for Sirius Satellite Radio Inc., to the Commission secretary. The petition was filed with the Commission on January 23, 2002.

3. UWB emissions in the FSS frequency bands

124. The Fixed Satellite Service (FSS) operates in the 3.7-4.2 GHz band. UWB devices are permitted to operate in this band at an emission level not to exceed -41.3 dBm/MHz.

125. Petition. SIA filed a Petition for Reconsideration stating that the Commission's analysis in the *R&O* of the interference potential to the FSS in the 3.7-4.2 GHz band is inconsistent because it develops a protection criteria based on indoor UWB operation but also permits those devices to operate outdoors.[295] SIA argues that the Commission relied on a building between the UWB emitter and the FSS earth station to serve as a buffer, but that this building attenuation cannot be assumed for outdoor UWB devices. It requests that the emissions from outdoor UWB devices be reduced in the FSS band, but does not specify a desired emission level. SIA also states that the Commission did not meaningfully address the minimum separation distances specified in the NTIA report for protecting FSS.[296] According to SIA, the NTIA separation distances ranged from 630 meters to tens of kilometers. SIA states that it is inevitable that UWB devices will be operated at closer distances to FSS earth stations than those calculated by NTIA.

126. Comments. XSI disagrees with SIA, stating that the Commission's rules requiring earth stations to be angled upwards by greater than 5 degrees raises the FSS antenna axis well above the 2 meter height employed by NTIA for evaluating outdoor UWB devices and provides at least 10 dB of isolation from outdoor UWB devices.[297] XSI therefore argues that the Commission was correct in its assessment because only an indoor UWB device, assumed to be operating at a height of 30 meters, represents a potential source of interference to FSS reception. XSI points out that the Commission noted that the FSS antenna would not point at a building since the building would block signals from the satellite.

127. Discussion. In the R&O, the Commission relied upon an analysis of NTIA's calculations to demonstrate that it is unlikely that harmful interference would be caused to FSS systems from UWB devices.[298] For a low-PRF UWB system operating outdoors at a 2 meter elevation, an emission limit of -51 dBm was specified by NTIA; for a low-PRF UWB system operating outdoors at a 30 meter elevation, an emission limit of -77 dBm was specified by NTIA.[299] The limits were based on NTIA's calculations employing an interference-to-noise ratio (I/N) of -10 dB. However, the Commission disagreed with the I/N employed by NTIA and instead used an I/N of 0 dB.[300] SIA did not dispute the use of a 0 dB I/N. This resulted in the emission limits from UWB devices in the FSS bands having to be attenuated to -41 dBm for outdoor UWB systems at a 2 meter elevation and to -67 dBm for outdoor UWB systems at a 30 meter elevation. Based on this analysis, the only UWB systems that exceed the NTIA calculated protection criteria are those at 30 meter elevations.[301] The Commission recognized that no outdoor UWB systems would be located 30 meters above a FSS antenna. UWB systems operating at this height are limited to systems located inside nearby buildings that themselves are at elevations higher than the FSS

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295 SIA comments at pg. 3-4.

296 *Id.* at pg. 4.

297 XSI comments at pg. 24-25 and attached technical analysis at pg. vii-viii.

298 NTIA Special Publication 01-43, *supra*.

299 Higher emission limits could be permitted with higher PRF UWB systems.

300 *R&O*, *supra*, at para. 140. The *R&O* referenced Section 2.3.1 of Appendix 7 of the (1998) ITU Radio Regulations in stating that digital FSS systems should be considered with an I/N ratio of 0 dB. Table II of the same Section indicates that analog FSS systems should be coordinated with an I/N ratio of -8 dB.

301 NTIA performed its analysis based on the UWB systems operating at heights of 2 meters and 30 meters. Any analysis of UWB systems operating at different heights, *e.g.*, 50 meters, should produce similar results.

antenna. The attenuation from the building in which the UWB device is operating is 12 dB, resulting in a need to reduce the emissions from indoor UWB devices to -55 dBm, a level that is 13.7 dB above the UWB emission limit of -41.3 dBm. However, FSS antennas are not pointed at a building, as the building would block the signals from the satellite. Based on the minimum FSS antenna performance standards,[302] the main beam of the FSS antenna must be offset from a UWB device located within the building by 4 degrees in the plane of the satellite and by 5 degrees in all other directions in order to achieve this additional 13.7 dB of attenuation. It is likely that the main beam of the FSS antenna is offset by at least 5 degrees from the building and by an even greater amount from a UWB device located within the building. Thus, the -41.3 dBm/MHz emission limit applied to UWB devices is sufficient to prevent harmful interference to FSS reception.

128. With respect to the separation distances calculated by NTIA and referenced by SIA in its petition, we note that these distances were based on output levels from UWB devices that considerably exceeded the limits proposed in the *Notice* or adopted in the *R&O*. Thus, the actual separation distances needed to prevent harmful interference are much smaller. Indeed, we have found that there is no threat of harmful interference from UWB systems operating under the current standards to FSS reception. Accordingly, we are denying SIA's Petition for Reconsideration.

129. On January 10, 2003, SIA submitted a technical analysis demonstrating a potential interference to FSS reception from peak emission levels radiated by UWB devices.[303] Having reviewed the submission, we are not convinced that SIA's recent filing demonstrates that the operation of UWB devices will cause harmful interference to FSS receivers. We believe that the interference scenario employed by SIA is overly conservative. For example, SIA assumes that the FSS receivers will operate with the antennas directed low towards the horizon, that the area surrounding the FSS antennas will be clear of obstacles for wide separation distances enabling the UWB RF energy to propagate towards the FSS antenna without any shielding, that the UWB device will emit peak emissions on the FSS frequencies directly towards the satellite receiver at the maximum level permitted under the rules, and that the FSS antenna will be only 6 meters higher than the height of the UWB device. The SIA study also is based on an I/N ratio of -10 dB. We recognize that FSS antennas generally are mounted in areas that are not readily accessible to the general public, *e.g.*, in secured areas. We also note that SIA assumes that FSS receivers will respond fully to the peak emissions from UWB devices.

130. When the Commission established the UWB standards, it prohibited fixed outdoor infrastructures. As a practical matter, only hand held UWB devices are permitted to operate outdoors in the FSS frequency bands.[304] These hand held devices would be used for peer to peer applications used to exchange data. High speed data transfers require the use of high pulse repetition frequencies which, in turn, result in the UWB devices having low peak-to-average ratios. Consequently, we believe that most outdoor UWB devices will be governed by the limit on the average emission levels and will not radiate emissions approaching the peak limit. Further, during inclement weather when the FSS receivers are receiving at the lowest emission levels from the satellite, it is unlikely that the hand held UWB devices will be operated outdoors.

131. Based on all of these factors, we are not convinced by SIA's latest submission that UWB

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302 47 C.F.R. § 25.209(a).

303 This analysis was submitted as an *ex parte* filing.

304 While imaging systems are permitted to operate outdoors in this frequency band, the FSS frequency bands are too high to be used by most imaging systems. Medical imaging systems may be able to operate in the FSS bands, but they are permitted only for indoor applications. It also may be feasible to operate surveillance systems in the FSS bands. Because of this, we recommend that parties operating FSS receivers be cautious in employing surveillance systems to protect their receiver sites.

devices will cause harmful interference to FSS reception or that the standards for UWB devices need to be changed. However, we intend to monitor closely the development of UWB devices and operations and will continue to examine interference issues as UWB products develop. We also intend to work with the FSS industry in developing an appropriate plan to perform further interference tests of UWB devices, including their potential impact on the reception of satellite signals. If our tests or other sources provide any indication that our standards are not adequate to protect any of the authorized radio services from harmful interference, we will take the appropriate action to protect those services.

4. UWB emissions in the aviation frequency bands

132. Except for vehicular radar systems, all UWB non-imaging devices operate in the 3.1-10.6 GHz band at an emission level not to exceed -41.3 dBm/MHz.

133. Petition. ARINC and ATA filed a joint Petition for Reconsideration requesting that all UWB operations, except for coordinated terrestrial imaging systems, be located above 5.5 GHz and that the average power limits between 3.1-5.5 GHz be reduced to -51.3 dBm for indoor UWB devices and to -61.3 dBm for handheld UWB devices.[305] They submit that this change is necessary to protect aeronautical telemetry systems (2.31-2.39 GHz), airport surveillance radars (2.7-2.9 GHz), radio altimeters (4.2-4.4 GHz), airborne weather radars (2.9-30., 5.0-5.25, and 5.35-5.47 GHz), and microwave landing systems (5.0-5.25 GHz). They also request that the coordination information for UWB imaging systems be posted on the Internet to permit quick access by licensees and users of licensed services, including GPS users, to enable enforcement of the non-interference requirements.[306] Finally, they request that all UWB devices, particularly consumer-oriented indoor and handheld devices, be labelled "Warning: Not for use on aircraft" with similar warnings to be placed in the operating manuals.[307]

134. Comments. XSI notes that all of the radio systems of concern to ARINC and ATA were thoroughly analyzed in the *R&O* or lie below 3.1 GHz and that the petition presents no technical basis for reconsideration.[308] XSI also opposes the labelling requirement, indicating that the Commission already prohibits the operation of UWB devices on board aircraft. Further, XSI adds that hand held devices, the only type of UWB product that passengers could conceivably operate on board an aircraft, already are subject to stringent emission limits. XSI also notes that a labelling requirement would raise design and manufacturing concerns, that a label in English would limit distribution of the product, and that it is unlikely that labelling would significantly affect compliance.

135. Discussion. We concur with XSI that the radio systems addressed by ARINC and by ATA were analyzed in the *R&O* or are below the frequency range employed by non-imaging UWB devices.[309] ARINC and ATA provide no technical support for their claims that the operation of UWB devices under the adopted standards will result in harmful interference. Rather, their request to require uncoordinated imaging systems to operate above 5.5. GHz is based solely on unsupported conjecture. Absent any evidence that UWB operation under the rules could result in harmful interference to the authorized radio services, we find no justification for the petitioners request to disseminate coordination information for imaging systems on the Internet. We also agree with XSI that there is no basis to require the labelling requested by ARINC and ATA. We are not persuaded that requiring UWB devices to be

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305 ARINC and ATA Petition for Reconsideration at pg. 4-5. This change would affect only indoor and hand held UWB devices.

306 *Id.* at pg. 5.

307 *Id.* at pg. 6.

308 XSI comments at pg. 26-27 and attached technical statement at pg. viii-ix.

309 *R&O*, *supra*, at para. 122-146.

labelled that they are not for use on board aircraft would affect compliance. At the emission limits adopted in the *R&O*, it was determined that UWB systems would not be a source of potential harmful interference to aviation radio operations. However, the Commission prohibited their operation onboard aircraft out of an abundance of caution. Accordingly, we are denying the Petition for Reconsideration filed by ARINC and ATA.

5. UWB emissions in the MDS and ITFS frequency bands

136. Multipoint Distribution Service (MDS) and Instructional Television Fixed Services (ITFS) systems are permitted to operate in the 2150-2162 MHz and 2500-2690 MHz bands.[310] UWB through-wall imaging systems and surveillance systems are permitted to operate in these bands at an emission level not to exceed -41.3 dBm/MHz. Emissions from all other UWB devices must be attenuated to -51.3 dBm/MHz or to -61.3 dBm/MHz, depending on the specific UWB equipment.

137. Comments. In its comments, WCA supports the Petition for Reconsideration filed by Sprint, but only to the extent that it requests that the same UWB emission limits adopted for PCS also be applied in the 2150-2162 MHz and 2500-2690 MHz bands used for Multipoint Distribution Service (MDS) and Instructional Television Fixed Service (ITFS).[311] WCA objects to the UWB emission limits for the MDS and ITFS bands as well as to the rules permitting UWB through-wall imaging systems and surveillance systems to operate within these bands.[312] It also asserts that the Commission's analysis of potential interference was based on an outmoded view of MDS/ITFS employing high-gain, directional antennas mounted without blockage between transmit and receive antennas, whereas now the large antennas have been replaced with smaller and lower power systems located at the customer's premise for two-way communications.[313] Thus, WCA indicates that these products would be more susceptible to interference from UWB emissions. It states that MDS/ITFS now is similar to PCS systems and adds that like services must be accorded like regulatory treatment.[314] Sprint concurs with WCA's comments.[315]

138. XSI argues that WCA provides no technical support in its disagreement with the Commission's analysis and does not even state the UWB emission level it believes to be appropriate for the MMDS and ITFS bands.[316] XSI adds that WCA ties its request to Sprint's petition regarding limits in the PCS band based on the justification that like services should be accorded like regulatory treatment.[317] However, it notes that MMDS and ITFS are not like PCS, citing that PCS services are subject to a presumption of mandatory Title II regulation. XSI also notes that WCA did not reference the millions of RF products that are permitted to place emissions in the MMDS/ITFS frequency bands at levels 10 to 20 dB higher than the limits adopted for indoor and handheld UWB devices.[318] Finally, XSI states that

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310 In its recent *Second Report and Order in the Advanced Wireless Services*, ET Docket No. 00-258, FCC 02-304, released November 5, 2002, the Commission reallocated the 2150-2155 MHz portion of the MDS/ITFS spectrum for new Advanced Wireless Services. It also indicated that it would identify any relocation spectrum for MDS licensees and craft appropriate relocation procedures in a separate rulemaking in the near future.

311 WCA comments at pg. 1.

312 *Id.* at pg. 2.

313 *Id.* at pg. 3-5.

314 *Id.* at pg. 7.

315 Sprint reply comments at pg. 23.

316 XSI reply comments at pg. 3. XSI also argues that WCA's comments are an untimely filed request for reconsideration, not comments.

317 *Id.* at pg. 4.

318 *Id*.

indoor, desktop MMDS/ITFS equipment will not operate at the same 35 mile range employed with outdoor-mounted video antennas, but rather will operate with a typical 1-3 mile cell architecture range with its greatest source of interference being other MMDS/ITFS systems.[319] XSI points out that emissions from adjacent MMDS/ITFS stations can be as high as 8 dBW at the edge of a 6 MHz wide channel and as high as 3 dBm in the center of a channel, overwhelming UWB signals. According to XSI, a MDS/ITFS receiver operating at the boundary of the licensed protected service area could be subject to an aggregate power flux density from MMDS/ITFS of -73 dBW/m^2, a signal approximately 12 dB more than can be expected from an indoor UWB emitter only one meter from the MMDS/ITFS receiver.

139. Discussion. WCA provides no technical information regarding the operation of MDS/ITFS two-way communication systems nor does it provide technical information to bolster its claim that MDS/ITFS short range communication systems require additional interference protection.[320] No information is provided to demonstrate that PCS operations, primarily using CDMA modulation, have any similarity to MDS/ITFS two-way stations. However, with the exception of through-wall imaging systems and surveillance systems, the emission levels from UWB devices permitted within the MDS and ITFS bands already are the same or are within 2 dB of the limits applicable to UWB emissions in the PCS bands. Because of the attenuation from the wall through which they are pointed, emissions from through-wall imaging systems are not expected to be a source of harmful interference. Surveillance systems are expected to be removed far enough from MDS/ITFS stations as to not be a concern, especially since the MDS/ITFS systems addressed by WCA are indoor systems and attenuation from the buildings in which they are located will lower the UWB emission levels.

140. We also note that the Commission, at the request of IPWireless, recently amended the rules to permit MDS/ITFS stations to emit higher level spurious emissions within their bands of operation.[321] Originally, ITFS and MDS transmitters were required to attenuate their emissions by at least 40 dB at 250 kHz from the channel edge and by 60 dB at 3 MHz and beyond from the channel edge. At the request of the users of these devices, the Commission relaxed the spurious emission limits for response stations from -6 dBW/6 MHz to 40 dB or 33 + 10 log (P) dB, whichever is the lesser attenuation, at 250 kHz from the channel edge and to 60 dB or 43 + 10 log (P) dB, whichever is the lesser attenuation, at 3 MHz and beyond from the channel edge.[322] An attenuation of 33 + 10 log (P) results in a limit of -3 dBm, and an attenuation of 43 + 10 log (P) results in a limit of -13 dBm. High power MDS/ITFS stations may emit even higher spurious emission levels, being subject only to the 40 dB and 60 dB attenuation caps. These limits are the levels conducted to the antenna and do not include the gain imparted by the antenna. Thus, the spurious emission limits applicable to MDS/ITFS stations will be considerably higher than the -41.3 dBm/MHz permitted from mid-frequency imaging systems and ever higher than the -50.3 to -61.3 dBm/MHz limits applied to all other UWB emitters.[323] Accordingly, we concur with XSI that it appears that the unwanted emissions from the MDS/ITFS stations will dominate the background noise level and should effectively mask the low level emissions permitted from UWB devices. Absent any relevant technical information from WCA, we can reach no other conclusion.

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[319] *Id.* at pg. 5.

[320] We concur with XSI that the WCA filing consists of untimely filed requests for reconsideration and is not a comment with regard to the timely filed petitions. This alone is sufficient to dismiss WCA's requests. However, in the interest of fair treatment of all of the issues raised by the various parties, we responding to the issues raised by WCA.

[321] *See Report and Order on Further Reconsideration and Further Notice of Proposed Rule Making* in MM Docket No. 97-217, 15 FCC Rcd 14566 (2000), at pg. 8-10.

[322] *See*, for example, 47 C.F.R. § 74.936(f).

[323] The level of -50.3 dBm/MHz is from the new UWB public safety communication systems, based on the applied antenna directionality, and is the same limit we are permitting in the PCS band.

141. In addition, we note that MDS and ITFS low power[324] fixed stations now are permitted to employ omnidirectional antennas in response to a request from IPWireless.[325] The use of such antennas were permitted originally under a waiver sought by Qualcomm that required all interference calculations involving the protection of low power, omnidirectional response stations to be performed as if those stations were using a directional antenna for reception. The requirement to employ directional antennas was intended to help minimize interference from one MDS/ITFS station to another. No consideration was given to the possibility that significant numbers of lower power response stations might be used as an integral part of an MDS or ITFS two-way system. The rules still base interference considerations on a 0.6 meter parabolic antenna and require the installation of a more suitable, *i.e.*, greater directionality, antenna should interference occur.[326] WCA provides no discussion on the relevance of this requirement and its resulting exposure of MDS/ITFS to greater threats of harmful interference.

142. Based on the above, we find that WCA has not provided any justification to support its argument that MDS/ITFS stations need additional interference protection from UWB operations nor has it supplied any information regarding the operating parameters of its equipment to determine what alternative interference criteria might be relevant. Accordingly, we find no basis to support an additional attenuation of UWB emissions falling within the MDS/ITFS frequency bands and deny WCA's request.

C. MSSI Petition for Reconsideration regarding non-UWB standards:

143. Under the rules, emissions from most Part 15 devices are measured using a CISPR quasi-peak detector. When an average emission limit is specified, the rules also specify a limit on the permitted amount of peak power equal to 20 dB more than the average limit.[327] Unless otherwise specified, a quasi-peak limit applies to emissions below 1000 MHz and an average limit applies to emissions above 1000 MHz. In some cases, a pulse desensitization correction factor (PDCF) must be applied to the measurement of a peak level obtained from a spectrum analyzer in order to compensate for the analyzer's inability to respond fast enough to pulse widths narrower than the inverse of the resolution bandwidth. The PDCF can considerably increase the measured peak emission level. This standard was employed when Part 15 devices used narrowband emissions, and unfairly penalizes transmission systems that use a wide bandwidth.

144. Petition. MSSI filed a Petition for Reconsideration requesting that peak emission measurements of its pulsed emission system operating under the non-UWB Part 15 regulations, *i.e.*, Subpart C of Part 15, be performed using a 1 MHz resolution bandwidth without the application of a pulse desensitization correction factor (PDCF).[328] Alternatively, MSSI requests that the peak power limit applied to UWB systems be reduced to the limit permitted under Subpart C of Part 15, *i.e.*, -21.25 dBm EIRP instead of the maximum limit of 0 dBm/50 MHz that currently applies to such devices. MSSI believes that the application of a PDCF was not required for measurements above 1000 MHz prior to May 14, 2002.[329] It bases this belief on a statement contained in the Public Notice announcing a waiver

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324 Low power refers to a maximum power of -6 dBW per 6 MHz channel.

325 *Report and Order on Further Reconsideration* in MM Docket No. 97-217, *supra*.

326 47 C.F.R. § 74.937(a).

327 47 C.F.R. § 15.35(b).

328 MSSI Petition for Reconsideration at pg. 9. The pulse desensitization correction factor is a technique used to determine the true pulse amplitude based on measurements taken from a spectrum analyzer. The analyzer is unable to respond fast enough and therefore does not use sufficient bandwidth to measure all of the energy in the pulsed signal. The pulse desensitization correction factor originally was designed specifically for measuring the peak output level of pulsed radar transmissions.

329 *Id.* at pg. 6.

granted to Time Domain Corporation, which stated that our rules require the application of a PDCF below 1000 MHz.[330] MSSI argues that the rules do not specifically state that a PDCF is required for peak measurements above 1000 MHz.

145. Comments. The US GPS Industry Council argues that granting MSSI's request to eliminate the use of a PDCF would result in peak power levels that are 41.25 dB higher than those specified in the rules.[331] MSSI disagrees, pointing out that it is the fraction of the total power appearing within the victim receiver bandwidth that causes the interference.[332]

146. Discussion. Eliminating the requirement to apply a PDCF for measuring peak emissions was not addressed in this proceeding and, thus, is outside of its scope. In addition, MSSI is in error with its claim that a PDCF was not required for the measurement of emissions above 1000 MHz from a pulsed modulated system prior to May 14, 2002. As discussed throughout this proceeding, the previous Part 15 regulations that precluded the operation of UWB devices included a requirement to apply a PDCF,[333] a prohibition against operation within the restricted bands,[334] and a prohibition against damped wave emissions.[335] Further, the requirement to apply a PDCF is contained in the instructions on how to operate a spectrum analyzer to measure pulsed emissions.[336] The rule cited by MSSI, 47 C.F.R. § 15.35(b), requires the use of a 1 MHz resolution bandwidth to measure the peak emission level. However, the PDCF must be applied to that measured value if the conditions specified in HP Application Note 150-2 are met. MSSI is incorrect in its assertion that an incomplete statement contained in the Public Notice announcing the issuance of a waiver overturns the discussions throughout this proceeding and negates the operating instructions for a spectrum analyzer, which clearly state that the application of a PDCF is required for peak emission measurements.[337] Accordingly, we are denying this portion of MSSI's Petition for Reconsideration. However, we agree with MSSI that the existing rule should be clarified rather than continue to rely on the spectrum analyzer operating instructions to indicate when a PDCF is required. We also recognize, as discussed in the *NOI* and in the *Notice*, that the existing peak limit for non-UWB operation is designed to accommodate narrowband systems and is not well suited to measure the operation of, or represent the interference potential of, recently-developed transmitters employing extremely wide bandwidths. Accordingly, we are proposing to amend the existing rule, as set forth below under the discussion on further rulemaking proposals, to provide a peak limit that will facilitate wide bandwidth transmission systems.

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330 *Id.* at pg. 2 and 3. *See*, also, Public Notice of July 8, 1999, "The Office of Engineering and Technology Grants Waivers for Ultra-Wide Band Technologies," DA 99-1340.

331 USGPSIC comments at pg. 8.

332 MSSI further comments at pg. 2-3. We agree that is the power that appears in the bandwidth of the victim receiver that is the potential source of interference. However, as already noted the current rules were based on the use of narrowband emissions and may unfairly penalize systems employing wide bandwidths.

333 *See NOI*, *supra*, at para. 5 and 13. *See Notice*, *supra*, at para. 4, 35, 48, 51, and 53. *See Order*, *supra*, at para. 8 and 236.

334 *See* 47 C.F.R. § 15.205.

335 *See* 47 C.F.R. §§ 2.201(f) and 15.5(d).

336 *See* HP Application Note 150-2.

337 The statement contained in the press release is obviously in error. A PDCF is applied only when there is a requirement to obtain a peak measurement of a pulsed emission. A limit on peak emission levels, requiring the peak measurement, occurs only when the emission levels are presented as average levels. *See* 47 C.F.R. § 15.35(b). However, many Part 15 emission limits below 960 MHz are performed using a CISPR quasi-peak detector and do not require a peak measurement. *See* 47 C.F.R. §§ 15.209(d) and 15.521(d). Thus, a statement that a PDCF is employed only for emission measurements below 1000 MHz must be incorrect.

IV. OTHER MATTERS

147. Ambient noise measurements. Subsequent to the public release of the UWB R&O in April, 2002, the Technical Research Branch (TRB) of the OET Laboratory Division commenced a measurement program to examine the existing levels of ambient RF signal energy present in the frequency bands used by GPS and Aeronautical Radionavigation systems. The objective of this effort was to empirically determine the ambient RF energy levels that would be experienced by a GPS receiver if it were operated at the measurement location within a time frame coincident with that over which the measurements were performed. In addition, spurious emissions generated by common electronic/electrical devices were also measured within the GPS frequency bands. This measurement effort represented a "first step" toward collecting the data necessary to perform an objective evaluation of assumptions inherent in the link budget analysis used to calculate the UWB emissions limit.

148. On October 22, 2002, a report documenting the results of this measurement effort was publicly released.[338] The results indicate variability in the existing ambient RF environment within the GPS frequency bands, dependent upon the measurement location. In general, the ambient RF energy levels present within the indoor measurement locations were greater than those levels measured at outdoor locations. This was particularly evident within those indoor environments where a high density of computers and/or other electronic equipment were in operation. In many cases, the measured levels were significantly higher than the established UWB emissions limit. The results of the measurement of common electronic/electrical devices revealed spurious emissions within the frequency bands registered to GPS, often at levels in excess of the UWB emissions limit, but also typically removed from the pass band of most GPS receivers. While the data collected as a part of this effort raises questions with regard to assumptions in the link budget analysis, it was recognized that the data set is of limited scope. Thus, it was determined that the data set accumulated from this effort, when considered independently, was not sufficient to base a relaxation of the existing UWB emissions limit.

149. Upon release of the report, a thirty-day period was established to accept public comments on the TRB measurement program and results. Eight parties responded by posting comments to the docket during this period. Cingular Wireless LLC, the Ground Penetrating Radar Industry Coalition, the Public Safety Wireless Network, QUALCOMM Incorporated, RF Metrics Corporation, Time Domain Corporation, the United States GPS Industry Council, and XtremeSpectrum, Inc. responded during the open public comment period. Appendix D of this document contains the TRB staff replies to those comments submitted with regard to the TRB measurement program.

150. Emissions from digital circuitry. We received an Application for Review of a grant of certification issued to Time Domain for its UWB transmitter along with an associated Request for Declaratory Ruling addressing the regulations regarding emissions from digital circuitry contained within UWB devices.[339] While these filings are being addressed in separate actions,[340] they demonstrate that we

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[338] FCC Project TRB 02-02 Report, *Measured Emissions Data for Use in Evaluating the Ultrawideband (UWB) Emissions Limits in the Frequency Bands Used by the Global Positioning System (GPS)*," ET Docket No. 98-153, October 22, 2002.

[339] The coalition filing the Application for Review and the Request for Declaratory Ruling consist of: Air Transport Association of America, Inc.; American Airlines; American Congress on Surveying and Mapping; ARINC; AT&T Wireless Services, Inc.; The Boeing Company; Delta Air Lines, Inc.; Garmin International, Inc.; General Aviation Manufacturers Association; Multispectral Solutions, Inc.; National Business Aviation Association, Inc.; NavCom Technology, Inc.; Nortel Networks, Inc.; Northwest Airlines, Inc.; NovAtel Inc.; PanAmSat Corporation; QUALCOMM Incorporated; Raytheon Company; Rockwell Collins, Inc.; Satellite Industry Association; Sirius Satellite Radio Inc.; Spatial Technologies Industry Association; Sprint Corporation; Tendler Cellular, Inc.; Trimble Navigation Ltd.; United Airlines; United States GPS Industry Council; and XM Radio Inc.

[340] *See*, *Memorandum Opinion and Order*, adopted February 10, 2003, FCC 03-28.

should clarify the regulation regarding limits on emissions produced by digital circuitry used within UWB devices.[341] A precise description of the digital emission limits was provided in the *R&O*.[342] However, the wording contained within the rules is not as clear. Accordingly, we are amending 47 C.F.R. § 15.521(c) to more closely comport with the text of the *R&O*. As this change to the regulations is interpretative and only clarifies a standard that already has been adopted, prior notice and public comment are unnecessary.[343]

151. Additional filings. Cingular filed a pleading on February 12, 2003, styled as a "Supplement to Petition for Reconsideration." This pleading raised a statutory argument regarding the Commission's authority to proceed with the authorization of UWB devices on an unlicensed basis. This pleading raised new arguments that were not contained in Cingular's original petition. Therefore, it is not really a supplement and constitutes a new petition for reconsideration that was filed untimely under Section 1.106(f) of the rules.[344] Further, even if it could be considered a supplement, Cingular did not file a motion for leave to accept the late-filed pleading as is required by Section 1.106(f). Finally, based upon a review of the Commission's files and representations made to Commission staff by counsel for several parties participating in this proceeding, it appears that copies of this pleading were not served by Cingular on other parties to the proceeding. All other materials filed in this proceeding on a timely basis and in accordance with the Commission's rules have been considered.

152. Rule organization. We have taken the opportunity provided by this rule making proceeding to reorganize the UWB regulations dealing with imaging systems. The original rules were separated into categories of low frequency imaging systems, mid-frequency imaging systems, and high frequency imaging systems. We have rewritten these rules along the operational categories of GPRs and wall imaging systems, through-wall imaging systems, surveillance systems and medical imaging systems. We believe that this reorganization provides clarity. As this reorganization does not encompass any actual changes to the standards contained in the regulations, prior notice and comment are not necessary.[345]

V. FURTHER NOTICE OF PROPOSED RULE MAKING

153. At this time, we do not intend to propose major changes to the UWB standards. We believe that any changes in these standards would be disruptive to the current industry product development efforts. However, as noted in the preceding text, the technical changes requested by MSSI and by Siemens VDO cannot be implemented without being addressed through a Further Notice of Proposed Rule Making. We are proposing changes for the specific purposes of accommodating the MSSI and Siemens VDO systems because we believe that the types of operations desired by these manufacturers merit consideration for authorization under our rules. We also are proposing one change to the non-UWB Part 15 standards to more appropriately reflect the interference criteria that should be applied to wide bandwidth transmitters that do not operate under the UWB standards. Finally, we are proposing to eliminate the UWB definition, believing that this definition actually could result in an increased interference potential to the authorized services.

154. Proposed changes to the UWB standards to accommodate the MSSI radar system. MSSI requests that UWB systems employing a low pulse repetition frequency (PRF) be permitted to operate in

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341 47 C.F.R. § 15.521(c).

342 *R&O, supra*, at para. 207.

343 5 U.S.C. 553(b).

344 47 C.F.R. § 1.106(f).

345 5 U.S.C. 553(b)(3)(B).

the 3.1 GHz to 10.6 GHz band for any type of application. MSSI specifically mentions vehicular radar systems as an example of such equipment. MSSI argues that low PRF systems have less potential to cause interference than UWB devices operating at a high PRF. We disagree. As demonstrated by NTIA, low PRF UWB systems can have a higher potential for causing interference than that of high PRF UWB systems.[346] However, the interference potential of UWB systems is minimized based on the standards contained in the rules. Operation with a low PRF results in closer frequency spacing of the spectral emission lines. This, in turn, increases the probability that emissions will appear within the bandwidth of a victim receiver. However, two emission standards limit the interference potential of low PRF emitters. First, the average emission limit above 960 MHz is based on the use of a 1 MHz resolution bandwidth (RBW). While UWB systems operating with PRFs lower than 1 MHz will have multiple spectral lines contained within the 1 MHz RBW, the level of each spectral line will be reduced so that the total energy within the 1 MHz RBW does not exceed the emission limit. Second, there is a limit on peak emissions. As the PRF decreases, the peak to average ratio increases, as described in Appendix E of the *R&O*. As the PRF decreases below a certain level, depending on the RBW used to measure the peak emission, the peak limit becomes the defining standard and the average emission level generated in a 1 MHz RBW decreases below the limit specified in the regulations. Accordingly, UWB devices employing a low PRF are limited in their output levels by the standard on peak emission levels, not by the standard on average emission levels.[347] It does not appear that these issues were considered by NTIA in its calculations nor could they have been as the UWB standards had not been established when NTIA issued its report.

155. It appears that MSSI may have anticipated that its equipment would be permitted to operate under the new UWB rules. While we do not concur with MSSI that low PRF UWB systems have a lower interference potential than high PRF equipment, we believe that further public comment should be obtained on MSSI's request. Accordingly, we propose to amend the rules to permit the operation of any UWB product under the UWB standards currently designated for hand held devices[348] as long as the PRF does not exceed 200 kHz and the equipment employs a pulsed or an impulse modulation. Comments are requested on whether a different PRF limit should be employed, if any other changes to the standards, including changes to the emission limits, are necessary to incorporate this addition to the type of UWB devices permitted to operate outdoors, or if the addition to the operation of outdoor UWB devices should be expanded only to include low PRF vehicular radar systems. Specific technical analyses supporting the comments are requested.

156. Proposed changes to the UWB standards to accommodate the Siemens VDO radar system. Siemens requests that we amend our rules to permit the operation of frequency hopping systems as vehicular radar systems in the 22-29 GHz band.[349] Siemens VDO requests that the radar systems be permitted to demonstrate compliance with the UWB definition and bandwidth requirements based on the bandwidth occupied by the transmitter over a 10 millisecond period. Siemens VDO also requests that vehicular radar systems be permitted to comply with the RMS average emission limits based on averaging over a 10 millisecond time period.

157. As indicated earlier in this MO&O, Siemens VDO provided information on its vehicular radar system in an *ex parte* filing submitted November 13, 2001. Our initial reaction is that the Siemens VDO system would not have any higher potential for causing harmful interference that would other UWB vehicular radar systems currently under development. We note Siemens VDO's claim that a 10 millisecond "averaging time" for its frequency hopping vehicular radar signals would make them similar

[346] NTIA Special Publication 01-43, *supra*.

[347] Conversely, high PRF systems would be limited by the average limit established under the rules and not by the peak limit.

[348] 47 C.F.R. § 15.519.

[349] Vehicular radar systems operate under the standards in 47 C.F.R. § 15.515.

to the non-frequency hopped UWB devices when the integration time of space borne passive sensors is taken into account. However, this claim is not justified. There is a wide range of integration times possible for space borne passive sensors. For example, in the 23.6-24.0 GHz band the AMSR sensor has a 2.6 millisecond integration time while the AMSU-A sensor has integration times of 158-165 milliseconds. Furthermore, these integration times could change for future satellites.

158. We believe that the requested rule changes from Siemens VDO for its radar application should be proposed so that we might obtain public comment. However, we also are concerned that radar systems using slightly different modulation techniques or radar systems operating in different bands where the victim receiver characteristics are different may have different interference potentials. Because of these interference concerns, we are not proposing to permit the use of frequency hopping systems under the UWB rules for any application other than vehicular radar systems operating in the 22-29 GHz band.

159. Our primary concern is not that the Siemens VDO equipment does not comply with the definition of a UWB system. Rather, we are concerned that the Siemens VDO radar system does not comply with the UWB standards using the measurement procedures currently employed for frequency hopping systems.[350] Thus, we are concerned about the possible interference aspects of this type of operation. For example, a UWB vehicular radar system that complies with the existing regulations will place a low level emission on a frequency at any given time. However, the Siemens VDO system momentarily will place a much higher level emission on that frequency. The Siemens VDO system depends on a time averaging of the emission, based on the level of the emission, the number of hops, the occupancy time at any given frequency, and the time period over which the emissions are averaged to demonstrate compliance with the average emission limits. The emission level being measured may not be a true RMS average emission but could be more similar to a time averaged emission. Thus, a victim receiver with a fast transient response may be more susceptible to interference from the Siemens VDO system than from other UWB systems. Siemens indicates that EESS systems operating in the 23.6-24.0 GHz band will not be able to tell the difference between a distributed number of frequency hopping systems operating under the standards requested by Siemens VDO and a similarly distributed number of wideband radars complying with existing vehicular radar standards. However, we are concerned about the potential impact on terrestrial users which may be exposed to relatively few, but nearby, vehicular radars as well as the impact to EESS operations. We request comments on whether the higher instantaneous power delivered by a frequency hopping system would cause harmful interference to these systems.[351]

160. We are not proposing to change the emission limits currently applied to UWB vehicular radar systems. Rather, we are proposing new measurement techniques that may accommodate frequency hopping systems as UWB vehicular radars. We propose to permit frequency hopping systems to operate under the provisions for UWB vehicular radar systems provided the minimum UWB bandwidth is achieved in no greater than 10 milliseconds and the transmitter complies with all other technical standards for UWB operation in the 22-29 GHz band. Compliance with the average emission limit would be based

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[350] As noted in para. 32 of the *R&O*, *supra*, the emissions from transmitters employing frequency hopping modulation are measured with the frequency hop stopped. *See* 47 C.F.R. § 15.31(c). While this regulation specifically addresses swept frequency devices, having been established prior to frequency hopping systems being permitted under the regulations, it also has been applied to frequency hopping systems. *See* Public Notice of March 30, 2000, *Filing and Measurement Guidelines for Frequency Hopping Spread Spectrum Systems*, DA 00-705. No other measurement procedures have been proposed or established for frequency hopping systems.

[351] At any point in time, there would be fewer hopping channel radars transmitting on the same frequency, but there would be a higher output level from these devices. Our concern for interference to terrestrial services is based on nearby vehicular radars rather than a general cumulative impact. A considerable number of nearby UWB radars may be required to come up to the same instantaneous level emitted by the Siemens wideband radar.

on measurement using a one megahertz resolution bandwidth (RBW), a video bandwidth equal to or greater than the RBW, an RMS detector function, and a maximum 10 millisecond averaging time. The peak measurement would be required to be performed as currently specified in the rules using a peak hold detector and shall be performed over a sufficiently long period that the peak levels being measured cease increasing. Comments are requested on these proposed measurement procedures. For example, should the peak measurement be performed with the hopping sequence stopped; should a different averaging time be employed; should the averaging time be based on the number of hops and the dwell time of the hops; and should a maximum time be specified within which all hopping channels must be used?

161. Comments also are sought on the measurement procedure that would be used to demonstrate compliance with the UWB bandwidth limit.[352] Siemens requests that the bandwidth be measured based on two different possible procedures described in the appendix to its petition.[353] Both of the procedures suggested by Siemens are performed with the frequency hopping system active. However, we are concerned that those procedures may not indicate the actual bandwidth employed by the system and the corresponding distribution of RF energy, depending on various technical parameters of the actual hopping system, *e.g.*, the distribution of the hopping channels, the dwell times for the hops, the number of hopping channels, the separation of the channels, the bandwidth of a single hopping channel, the number of hops in a specified time period, etc. Thus, we propose that the bandwidth be measured by first measuring the -10 dB bandwidth of a single hopping channel based on use of a peak hold detector and a 1 MHz resolution bandwidth, determining how many non-overlapping hops occur within a 10 millisecond period and multiplying the two values. Comments are requested on this proposed measurement procedure as well as the procedures described by the petitioner. Comments also are requested on any interference concerns that arise from this new modulation type or its method of measurement. The comments should address specific interference concerns such as possible interference to Amateur Radio Service operations, including amateur satellite systems, to EESS operation, and to police radar operations and should include a technical justification. We request comments on whether the compliance measurement procedure proposed by the petitioner is applicable only to systems that are similar to its vehicular radar system or if they are applicable to vehicular radar systems in general. Do the various system parameters need to be limited to a specific range of values for the measurements to be meaningful? If so, what is the range of parameters over which the limits are to be applied? Can a general measurement procedure be developed that is applicable for a full range of system parameters? If so, what is this measurement procedure? The measurement procedure proposed by the petitioner involves a power measurement over a 10 millisecond averaging time period. Comments are requested as to whether these time averaged measurements should be made using a spectrum analyzer in a swept frequency mode or should the spectrum analyzer be stepped across the frequency band of interest in discrete steps with a defined dwell time at each step. Comments also are requested on the adequacy of the measurement results for the purpose of quantifying the impact to systems that could receive interference from the frequency hopping vehicular radar systems. Comments also are requested on any limits that should be applied to the number of hopping channels, the maximum occupancy time permitted for a hopping channel during any full hopping sequence, the maximum time it takes to complete a full hopping sequence, and any other pertinent technical characteristics.

162. Proposed changes to the non-UWB standards to accommodate wideband Part 15 transmitters. Throughout this proceeding, the Commission recognized that the peak emission limit specified in 47 C.F.R. § 15.35(b) was established based on the operation of narrowband transmission systems and may unfairly penalize some wideband operations. MSSI has provided an example of a

[352] Note that we also propose to eliminate the minimum UWB bandwidth standards which could make this issue moot.

[353] Siemens Petition for Reconsideration at Appendix A, pg. 16-17. These measurement procedures are incorporated by reference into this Further Notice of Proposed Rule Making.

wideband system that could operate under the Part 15 average general emission limits but cannot comply with the peak emission limit due to the wide bandwidth of the transmission. For Part 15 devices other than UWB devices, the total peak output power of the transmission must be measured. The UWB standards permit the peak power to be measured over a specified bandwidth, rather than over the entire bandwidth of the transmission. As stated in the *R&O*, the total peak power produced by the UWB device is not relevant to interference potential as there are no receivers employed in the authorized radio services that operate at the bandwidths used by UWB systems.[354] The widest bandwidth that would be employed by victim radio receivers is about 50 MHz. We believe that the current limit on peak emissions from Part 15 intentional radiators could be amended to reflect a limit similar to that adopted in the *R&O* for UWB systems. This would eliminate the bias under the Part 15 regulations towards narrowband operation.

163. Under the UWB regulations, the EIRP limit on peak emissions is 0 dBm based on the use of a 50 MHz resolution bandwidth (RBW).[355] A lower RBW may be employed, down to as low as 1 MHz, provided the peak limit is similarly reduced to the level 20 log (RBW/50) dBm EIRP, where RBW is the resolution bandwidth in megahertz. UWB systems also must operate with a -10 dB fractional bandwidth of at least 0.2 or have a -10 dB bandwidth of at least 500 MHz, whichever is less .[356] Below 2.5 GHz, the fractional bandwidth is dominant and above 2.5 GHz the 500 MHz bandwidth limit dominates. Because we appear to be dealing primarily with systems operating above 2.5 GHz, we will employ the 500 MHz minimum UWB bandwidth as a guideline for simplicity. Thus, the maximum resolution bandwidth that is used to measure peak limit for UWB emitters is one-tenth of the minimum UWB bandwidth. Accordingly, it appears that a peak limit, equivalent to the UWB standards, can be established for conventional Part 15 devices based on a limit of 20 log (RBW/50) dBm EIRP where RBW is the resolution bandwidth of the measurement instrument in megahertz and where RBW must not be greater than one-tenth of the -10 dB bandwidth of the emission being measured.

164. We propose to amend 47 C.F.R. § 15.35(b) to clarify the existing requirements as requested by MSSI, and to provide an alternative standard for wideband Part 15 transmission systems. Specifically, we propose to amend 47 C.F.R. § 15.35(b) to read as follows:

> (b) Unless otherwise specified, on any frequency or frequencies above 1000 MHz, the radiated emission limits are based on the use of measurement instrumentation employing an average detector function. Unless otherwise specified, average measurements above 1000 MHz shall be performed using a minimum resolution bandwidth of 1 MHz. When average radiated emission measurements are specified in this part, including emission measurements below 1000 MHz, there also is a limit on the peak radio frequency emissions. UWB devices operating under Subpart F of this part shall comply with the peak limits specified in that subpart. For all other Part 15 devices subject to limits based on average radiated emissions, the peak level shall comply with one of the following two levels, at the option of the responsible party:
>
> > (1) Unless a different peak limit is specified in the rules, *e.g.*, see § 15.255 of this chapter, the total peak power shall not exceed by more than 20 dB the average limit permitted at the frequency being investigated. Note that a pulse desensitization correction factor may be required to measure the total peak emission level.

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354 *R&O*, *supra*, at para. 214.

355 In order to accurately measure a peak signal, the video bandwidth must not be less than the RBW.

356 The factional bandwidth is the UWB bandwidth, *i.e.*, the -10 dB bandwidth, divided by the center frequency. *See* 47 C.F.R. § 15.503(c).

(2) The peak power shall not exceed an EIRP of 20 log (RBW/50) dBm where RBW is the resolution bandwidth in MHz employed by the measurement instrument. The RBW may not be lower than 1 MHz or greater than 50 MHz. Further, the RBW used in the measurement instrument shall not be greater than one-tenth of the -10 dB bandwidth of the device under test.

165. Comments are requested on this proposal. Comments also are requested on the alternative proposal presented by MSSI, namely should the rules be amended to permit devices operating above 1000 MHz under the Part 15 general emission standards in 47 C.F.R. § 15.209 to comply with a peak emission limit of 5000 uV/m at 3 meters based on a measurement using a peak detector, a 1 MHz resolution bandwidth and a video bandwidth no less than 1 MHz? We request comments on any changes to the interference potential of wideband Part 15 devices that may occur as a result of these proposals. Technical support is requested for comments arguing interference concerns.

166. UWB definition. We are sympathetic to the concerns expressed by MSSI, Siemens and others throughout this proceeding regarding the changes in operational standards for unlicensed devices that may apply simply due to the bandwidth of the transmission system. The Commission's standards in Part 15 need to reflect limits that reduce the potential for causing harmful interference to authorized radio services. While the emission limits applied to UWB operations ensure a low probability of causing harmful interference, they also require that the transmissions occupy a minimum bandwidth of 500 MHz or a minimum fractional bandwidth of 0.20. This minimum bandwidth requirement could cause a manufacturer to design transmitters that occupy more bandwidth than is operationally necessary or transmitters that inject noise to increase the occupied bandwidth simply to permit operation under the UWB regulations. Such systems would place greater energy in frequency bands where operation is not necessary for the system to function. Thus, a minimum bandwidth standard can be counterproductive to reducing the potential for harmful interference.[357] For this reason, we are proposing to eliminate the definition of an ultra-wideband transmitter in 47 C.F.R. § 15.503(d). In its place, we would permit the operation of any transmission system, regardless of its bandwidth, as long as it complies with the standards for UWB operation set forth in Subpart F of 47 C.F.R. Part 15. We also propose to change the limit on peak power to the same limit we proposed above for non-UWB operation. This will ensure that excessive peak power levels are not permitted from narrowband systems.[358] Comments are requested on this proposal. We request comments on any potential increase or decrease in interference potential to authorized radio services that could be caused by the adoption of this proposal. The comments should address the interference potential from narrowband systems operating under the UWB regulations. The comments also should address whether additional standards, such as a spectral power density limit based on a bandwidth narrower than 1 MHz, are needed. All comments should be based on a technical analysis of the interference potential.

VI. ADMINISTRATIVE PROVISIONS

A. Memorandum Opinion and Order

167. Paperwork Reduction Act of 1995 Analysis. This Memorandum Opinion and Order contains a modified information collection subject to the Paperwork Reduction Act of 1995 (PRA), Public

[357] It is the limit on emission levels, particularly the limit on spectral power density, that primarily controls interference potential.

[358] Because of the requirement that the RBW used in the 20 log (RBW/50) dBm peak power formula must be no greater than the -10 dB bandwidth of the emission, UWB devices would be required to have a -10 dB bandwidth of at least 1 MHz to use the peak power formula of 20 log (RBW/50) dBm, and must employ a -10 dB bandwidth of at least 500 MHz in order to employ a 50 MHz RBW. Transmission systems with narrower bandwidths would have to operate under the peak power limit currently applied to narrowband Part 15 transmissions.

Law 104-13. It will be submitted to the Office of Management and Budget (OMB) for review under Section 3507(d) of the PRA. OMB, the general public and other Federal agencies are invited to comment on the modified information collection contained in this proceeding.

168. Final Regulatory Flexibility Certification. The Regulatory Flexibility Act of 1980, as amended (RFA)[359] requires that a regulatory flexibility analysis be prepared for rulemaking proceedings, unless the agency certifies that "the rule will not have a significant economic impact on a substantial number of small entities."[360] The RFA generally defines "small entity" as having the same meaning as the terms "small business," "small organization," and "small governmental jurisdiction."[361] In addition, the term "small business" has the same meaning as the term "small business concern" under the Small Business Act.[362] A small business concern is one which: (1) is independently owned and operated; (2) is not dominant in its field of operation; and (3) satisfies any additional criteria established by the Small Business Administration (SBA).[363]

169. In this Memorandum Opinion and Order, we are responding to fourteen petitions for reconsideration regarding new rules adopted to permit the marketing and operation of new products incorporating ultra-wideband ("UWB") technology. UWB devices operate by employing very narrow or short duration pulses that result in very large or wideband transmission bandwidths. With appropriate technical standards, UWB devices can operate on spectrum occupied by existing radio services without causing interference, thereby permitting scarce spectrum resources to be used more efficiently. Further, as noted in the text we have continued to apply conservative limits to the standards applicable for UWB operation, until such time as we gain additional experience, to ensure that harmful interference would not be caused to other radio spectrum users. Further, the changes adopted in this proceeding will not affect any party legally manufacturing or marketing UWB devices. Thus, we expect that our actions do not amount to a significant economic impact. Accordingly, we certify that the rules being adopted in this Memorandum Opinion and Order will not have a significant economic impact on a substantial number of small entities.

170. We will send a copy of the Memorandum Opinion and Order, including a copy of this Final Regulatory Flexibility Certification, in a report to Congress pursuant to the Congressional Review Act.[364] In addition, the Memorandum Opinion and Order and this certification will be sent to the Chief Counsel for Advocacy of the Small Business Administration, and will be published in the Federal Register.[365]

171. Ordering Clauses. IT IS ORDERED that the Petitions for Reconsideration from MSSI,

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[359] The RFA, *see* § 5 U.S.C. S 601 *et. seq*., has been amended by the Contract With America Advancement Act of 1996, Pub. L. No. 104-121, 110 Stat. 847 (1996) (CWAAA). Title II of the CWAAA is the Small Business Regulatory Enforcement Fairness Act of 1996 (SBREFA).

[360] 5 U.S.C. § 605(b).

[361] 5 U.S.C. § 601(6).

[362] 5 U.S.C. § 601(3) (incorporating by reference the definition of "small business concern" in Small Business Act, 15 U.S.C. S § 632). Pursuant to 5 U.S.C. § 601(3), the statutory definition of a small business applies "unless an agency, after consultation with the Office of Advocacy of the Small Business Administration and after opportunity for public comment, establishes one or more definitions of such term which are appropriate to the activities of the agency and publishes such definition(s) in the Federal Register."

[363] Small Business Act 15 U.S.C. § 632.

[364] *See* 5 U.S.C. § 801(a)(1)(A).

[365] *See* 5 U.S.C. § 605(b).

Siemens VDO, Time Domain, AGA and APGA, GPRIC, GPR Providers, and NUCA ARE GRANTED to the extent described above. IT ALSO IS ORDERED that the Petitions for Reconsideration from Kohler, MSSI, Siemens, GPRIC, GPR Providers, Cingular, Qualcomm, Sprint, Sirius and XM, ARINC and ATA, and SIA ARE DENIED to the extent described above. IT ALSO IS ORDERED that Part 15 of the Commission's Rules and Regulations IS AMENDED as specified in Appendix B, effective 30 days after publication in the Federal Register. This action is taken pursuant to Sections 4(i), 302, 303(e), 303(f), 303(r), 304 and 307 of the Communications Act of 1934, as amended, 47 U.S.C. Sections 154(i), 302, 303(e), 303(f), 303(r), 304 and 307.

172. IT IS FURTHER ORDERED that the Commission's Consumer and Governmental Affairs Bureau, Reference Information Center, SHALL SEND a copy of this Memorandum Opinion and Order, including the Final Regulatory Flexibility Certification, to the Chief Counsel for Advocacy of the Small Business Administration.

B. Further Notice of Proposed Rule Making

173. As required by Section 603 of the Regulatory Flexibility Act, 5 U.S.C. § 603, the Commission has prepared an Initial Regulatory Flexibility Analysis (IRFA) of the expected impact on small entities of the proposals suggested in this document. The IRFA is set forth in Appendix A. Written public comments are requested on the IRFA. These comments must be filed in accordance with the same filing deadlines as comments on the rest of the Further Notice of Proposed Rule Making *("*Further Notice*")*, but they must have a separate and distinct heading designating them as responses to the IRFA. The Commission's Consumer Information Bureau, Reference Information Center, SHALL SEND a copy of this Further Notice, including the IRFA, to the Chief Counsel for Advocacy of the Small Business Administration in accordance with Section 603(a) of the Regulatory Flexibility Act, 5 U.S.C. § 603(a).

174. This is a permit-but-disclose notice and comment rulemaking proceeding. *Ex parte* presentations are permitted, except during the Sunshine Agenda period, provided they are disclosed as provided in the Commission's rules. *See generally* 47 C.F.R. §§ 1.1202, 1.1203, and 1.2306(a).

175. Pursuant to Sections 1.415 and 1.419 of the Commission's Rules, 47 C.F.R. §§ 1.415 and 1.419, interested parties may file comments on or before **90 days after date of publication in the Federal Register** and reply comments on or before **120 days after date of publication in the Federal Register**. Comments may be filed using the Commission's Electronic Comment Filing System (ECFS), http://www.fcc.gov/e-file/ecfs.html, or by filing paper copies. *See Electronic Filing of Documents in Rulemaking Proceedings*, 63 Fed. Reg. 23,121 (1998).

176. Comments filed through the ECFS can be sent as an electronic file via the Internet to http://www.fcc.gov/e-file/ecfs.html. Generally, only one copy of an electronic submission must be filed. If multiple docket or rulemaking numbers appear in the caption of this proceeding, however, commenters must transmit one electronic copy of the comments to each docket or rulemaking number referenced in the caption. In completing the transmittal screen, commenters should include their full name, Postal Service mailing address, and the applicable docket or rulemaking number. Parties may also submit an electronic comment by Internet e-mail. To get filing instructions for e-mail comments, commenters should send an e-mail to ecfs@fcc.gov, and should including the following words in the body of the message, "get form <your e-mail address." A sample form and directions will be sent in reply.

177. Parties who choose to file by paper must file an original and four copies of each filing. If more than one docket or rulemaking number appears in the caption of this proceeding, commenters must submit two additional copies for each additional docket or rulemaking number. All filings must be sent to the Commission's Secretary, Marlene H. Dortch, Office of the Secretary, Federal Communications Commission, 445 12th Street, S.W., TW-A325, Washington, D.C. 20554. Comments and reply comments will be available for public inspection during regular business hours in the FCC Reference Center of the

Federal Communications Commission, Room TW-A306, 445 12th Street, S.W., Washington, D.C. 20554.

178. The proposed action is authorized under Sections 4(i), 301, 302, 303(e), 303(f), 303(r), 304 and 307 of the Communications Act of 1934, as amended, 47 USC Sections 154(i), 301, 302, 303(e), 303(f), 303(r), 304, and 307.

179. For further information regarding this Memorandum Opinion and Order and Further Notice of Proposed Rule Making, contact John A. Reed, Office of Engineering and Technology, (202) 418-2455, jreed@fcc.gov.

FEDERAL COMMUNICATIONS COMMISSION

Marlene H. Dortch
Secretary

Appendix A
Initial Regulatory Flexibility Analysis

Initial Regulatory Flexibility Analysis

As required by Section 603 of the Regulatory Flexibility Act,[366] the Commission has prepared an Initial Regulatory Flexibility Analysis (IRFA) of the expected significant economic impact on small entities by the policies and rules proposed in this Further Notice of Proposed Rule Making *("*Further Notice*")*. Written public comments are requested on the IRFA. Comments must be identified as responses to the IRFA and must be filed by the deadlines for comments on the Further Notice provided in paragraph 175 of the item. The Commission shall send a copy of this Further Notice, including the IRFA, to the Chief Counsel for Advocacy of the Small Business Administration in accordance with paragraph 603(a) of the Regulatory Flexibility Act. In addition, the Further Notice and the IRFA (or summaries thereof) will be published in the Federal Register.[367]

A. Reason for Action.

This rulemaking proposal is initiated to obtain comments regarding proposed changes to the regulations for radio frequency devices that do not require a license to operate. The Commission seeks to determine if its standards should be amended to permit the operation of vehicular radar and other low-pulse repetition frequency outdoor UWB devices in the 3.1-10.6 GHz band and to permit the operation of frequency hopping vehicular radar systems in the 22-29 GHz band under the UWB regulations. It also seeks to amend the peak power limit on non-UWB unlicensed devices.

B. Legal Basis.

The proposed action is taken pursuant to Sections 4(i), 301, 302, 303(e), 303(f), 303(r), 304 and 307 of the Communications Act 10 1934, as amended, 47 U.S.C. Sections 154(i), 301, 302, 303(e), 303(f), 303(r), 304, and 307.

C. Description and Estimate of the Number of Small Entities to Which the Proposed Rules Will Apply.

The RFA directs agencies to provide a description of, and where feasible, an estimate of the number of small entities that may be affected by the proposed rules, if adopted.[368] The RFA generally defines the term "small entity" as having the same meaning as the terms "small business," "small organization," and "small governmental jurisdiction."[369] In addition, the term "small business" has the same meaning as the term "small business concern" under the Small Business Act.[370] A "small business concern" is one which: (1) is independently owned and operated; (2) is not dominant in its field of

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366 5 U.S.C. § 603.

367 5 U.S.C. § 603(a).

368 5 U.S.C. § 603(b)(3).

369 5 U.S.C. § 601(6).

370 5 U.S.C. § 601(3) (incorporating by reference the definition of "small-business concern" in the Small Business Act, 15 U.S.C. § 632). Pursuant to 5 U.S.C. § 601(3), the statutory definition of a small business applies "unless an agency, after consultation with the Office of Advocacy of the Small Business Administration and after opportunity for public comment, establishes one or more definitions of such term which are appropriate to the activities of the agency and publishes such definition(s) in the Federal Register."

operation; and (3) satisfies any additional criteria established by the Small Business Administration (SBA).[371]

A small organization is generally "any not-for-profit enterprise which is independently owned and operated and is not dominant in its field."[372] Nationwide, as of 1992, there were approximately 275,801 small organizations.[373] "Small governmental jurisdiction"[374] generally means "governments of cities, counties, towns, townships, villages, school districts, or special districts, with a population of less than 50,000."[375] As of 1992, there were approximately 85,006 governmental entities, total, in the United States.[376] This number includes 38,978 cities, counties, and towns; of these, 37,566, or 96%, have populations of fewer than 50,000.[377] The Census Bureau estimates that this ratio is approximately accurate for all governmental entities. Thus, of the 85,006 governmental entities, we estimate that 81,600 (96%) are small entities. Nationwide, as of 1992, there were 4.44 million small business firms, according to SBA data.[378]

The SBA has developed a small business size standard for wireless firms within the two broad economic census categories of Paging[379] and Cellular and Other Wireless Telecommunications.[380] Under both SBA categories, a wireless business is small if it has 1,500 or fewer employees. For the census category of Paging, Census Bureau data for 1997 show that there were 1320 firms in this category, total, that operated for the entire year.[381] Of this total, 1303 firms had employment of 999 or fewer employees, and an additional 17 firms had employment of 1,000 employees or more.[382] Thus, under this category and associated small business size standard, the great majority of firms can be considered small. For the census category Cellular and Other Wireless Telecommunications firms, Census Bureau data for 1997 show that there were 977 firms in this category, total, that operated for the entire year.[383] Of this total, 965 firms had employment of 999 or fewer employees, and an additional 12 firms had employment of 1,000 employees or more.[384] Thus, under this second category and size standard, the great majority of firms can, again, be considered small.

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371 15 U.S.C. § 632.

372 5 U.S.C. § 601(4).

373 U.S. Department of Commerce, Bureau of the Census, 1992 Economic Census, Table 6 (special tabulation of data under contract to the Office of Advocacy of the U.S. Small Business Administration).

374 47 CFR § 1.1162.

375 5 U.S.C. § 601(5).

376 U.S. Department of Commerce, Bureau of the Census, 1992 Census of Governments.

377 U.S. Department of Commerce, Bureau of the Census, 1992 Census of Governments.

378 U.S. Department of Commerce, Bureau of the Census, 1992 Census of Transportation, Communications, and Utilities, UC 92-S-1, Subject Series, Establishment and Firm Size, Table 2D, Employment Size of Firms.

379 13 CFR § 121.201, NAICS code 513321 (changed to 517211 in October 2002).

380 13 C.F.R. § 121.201, NAICS code 513322 (changed to 517212 in October 2002).

381 U.S. Census Bureau, 1997 Economic Census, Subject Series: Information, "Employment Size of Firms Subject to Federal Income Tax: 1997," Table 5, NAICS code 513321 (issued Oct. 2000).

382 *Id*. The census data do not provide a more precise estimate of the number of firms that have employment of 1,500 or fewer employees; the largest category provided is "Firms with 1,000 employees or more."

383 U.S. Census Bureau, 1997 Economic Census, Subject Series: Information, "Employment Size of Firms Subject to Federal Income Tax: 1997," Table 5, NAICS code 513322 (issued Oct. 2000).

384 *Id*. The census data do not provide a more precise estimate of the number of firms that have employment of 1,500 or fewer employees; the largest category provided is "Firms with 1,000 employees or more."

The SBA has established a small business size standard for *Radio and Television Broadcasting and Wireless Communications Equipment Manufacturing*. Under this standard, firms are considered small if they 750 or fewer employees.[385] Census Bureau data for 1997 indicate that, for that year, there were a total of 1,215 establishments in this category.[386] Of those, there were 1,150 that had employment under 500, and an additional 37 that had employment of 500 to 999. Thus, under this size standard, the majority of establishments can be considered small.

SatelliteTelecommunications The SBA has developed a small business size standard for Satellite Telecommunications Carriers, which consists of all such companies having $12.5 million or less in annual receipts.[387] In addition, a second SBA size standard for Other Telecommunications includes "facilities operationally connected with one or more terrestrial communications systems and capable of transmitting telecommunications to or receiving telecommunications from satellite systems,"[388] and also has a size standard of annual receipts of $12.5 million or less. According to Census Bureau data for 1997, there were 324 firms in the category Satellite Telecommunications, total, that operated for the entire year.[389] Of this total, 273 firms had annual receipts of $5 million to $9,999,999 and an additional 24 firms had annual receipts of $10 million to $24,999,990.[390] Thus, under this size standard, the majority of firms can be considered small. In addition, according to Census Bureau data for 1997, there were 439 firms in the category Satellite Telecommunications, total, that operated for the entire year.[391] Of this total, 424 firms had annual receipts of $5 million to $9,999,999 and an additional 6 firms had annual receipts of $10 million to $24,999,990.[392] Thus, under this second size standard, the majority of firms can be considered small.

As no party currently is permitted to market or operate the proposed UWB standards, there will not be any impact on any small entities. On the other hand, the proposed change in the limit on peak power levels may relax the current emission limit for wideband transmission systems. The Commission does not have an estimated number for the small entities that may produce such products but believes that there are only a few in existence.

D. Description of Projected Reporting, Recordkeeping and Other Compliance Requirements for Small Entities.

Part 15 transmitters are already required to be authorized under the Commission's certification procedure as a prerequisite to marketing and importation. The reporting and recordkeeping requirements associated with these equipment authorizations would not be changed by the proposals contained in this *Notice*. These changes to the regulations would permit the introduction of an entirely new category of radio transmitters. The change in the method of measuring peak power for wideband transmitters will result in a slight relaxation of the peak power limit standard on these devices.

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385 13 C.F.R. § 121.201, NAICS code 334220.

386 U.S. Census Bureau, 1977 Economic Census, Industry Series: Manufacturing, "Industry Statistics by Employment Size," Table 4, NAICS code 334220 (issued August 1999).

387 13 C.F. R. § 121.201, North American Industry Classification System (NAICS) code 517410 (formerly 513340).

388 *Id*. NAICS code 517910 (formerly 513390).

389 U.S. Census Bureau, 1997 Economic Census, Subject Series: Information, "Receipt Size of Firms Subject to Federal Income Tax: 1997," Table 4, NAICS code 517410 (issued Oct. 2000).

390 *Id*.

391 U.S. Census Bureau, 1997 Economic Census, Subject Series: Information, "Receipt Size of Firms Subject to Federal Income Tax: 1997," Table 4, NAICS code 517910 (issued Oct. 2000).

392 *Id*.

E. Steps Taken to Minimize the Significant Economic Impact on Small Entities, and Significant Alternatives Considered.

The RFA requires an agency to describe any significant, specifically small business, alternatives that it has considered in reaching its proposed approach, which may include the following four alternatives (among others): "(1) the establishment of differing compliance or reporting requirements or timetables that take into account the resources available to small entities; (2) the clarification, consolidation, or simplification of compliance and reporting requirements under the rule for such small entities; (3) the use of performance rather than design standards; and (4) an exemption from coverage of the rule, or any part thereof, for such small entities."[393]

The standards proposed in this proceeding are based on equipment performance and not on equipment design. As no party currently is permitted to market or operate the proposed UWB standards, there will not be any impact on any small entities. On the other hand, the proposed change in the limit on peak power levels may relax the current emission limit for wideband transmission systems.

F. Federal Rules that May Duplicate, Overlap, or Conflict with the Proposed Rule.

None.

[393] 5 U.S.C. § 603(c)(1) – (c)(4).

Appendix B
Changes to the Regulations

Title 47 of the Code of Federal Regulations, Part 15, is amended as follows:

1. The authority citation for Part 15 continues to read as follows:

AUTHORITY: 47 U.S.C. 154, 302, 303, 304, 307 and 544A.

2. Section 15.509 is replaced, to read as follows:

Section 15.509 Technical requirements for ground penetrating radars and wall imaging systems.

(a) The UWB bandwidth of an imaging system operating under the provisions of this section must be below 10.6 GHz.

(b) Operation under the provisions of this section is limited to GPRs and wall imaging systems operated for purposes associated with law enforcement, fire fighting, emergency rescue, scientific research, commercial mining, or construction.

(1) Parties operating this equipment must be eligible for licensing under the provisions of Part 90 of this chapter.

(2) The operation of imaging systems under this section requires coordination, as detailed in Section 15.525 of this part.

(c) A GPR that is designed to be operated while being hand held and a wall imaging system shall contain a manually operated switch that causes the transmitter to cease operation within 10 seconds of being released by the operator. In lieu of a switch located on the imaging system, it is permissible to operate an imaging system by remote control provided the imaging system ceases transmission within 10 seconds of the remote switch being released by the operator.

(d) The radiated emissions at or below 960 MHz from a device operating under the provisions of this section shall not exceed the emission levels in Section 15.209. The radiated emissions above 960 MHz from a device operating under the provisions of this section shall not exceed the following average limits when measured using a resolution bandwidth of 1 MHz:

Frequency in MHz	EIRP in dBm
960-1610	-65.3
1610-1990	-53.3
1990-3100	-51.3
3100-10600	-41.3
Above 10600	-51.3

(e) In addition to the radiated emission limits specified in the table in paragraph (d) of this section, UWB transmitters operating under the provisions of this section shall not exceed the following average limits when measured using a resolution bandwidth of no less than 1 kHz:

Frequency in MHz	EIRP in dBm
1164-1240	-75.3
1559-1610	-75.3

(f) For UWB devices where the frequency at which the highest radiated emission occurs, f_M, is above 960 MHz, there is a limit on the peak level of the emissions contained within a 50 MHz bandwidth centered on f_M. That limit is 0 dBm EIRP. It is acceptable to employ a different resolution bandwidth, and a correspondingly different peak emission limit, following the procedures described in Section 15.521.

3. A new Section 15.510 is added to read as follows:

Section 15.510 Technical requirements for through-wall imaging systems.

(a) The UWB bandwidth of an imaging system operating under the provisions of this section must be below 960 MHz or the center frequency, f_C, and the frequency at which the highest radiated emission occurs, f_M, must be contained between 1990 MHz and 10600 MHz.

(b) Operation under the provisions of this section is limited to through-wall imaging systems operated by law enforcement, emergency rescue or firefighting organizations that are under the authority of a local or state government.

(c) For through-wall imaging systems operating with the UWB bandwidth below 960 MHz:

(1) Parties operating this equipment must be eligible for licensing under the provisions of Part 90 of this chapter.

(2) The operation of these imaging systems requires coordination, as detailed in Section 15.525.

(3) The imaging system shall contain a manually operated switch that causes the transmitter to cease operation within 10 seconds of being released by the operator. In lieu of a switch located on the imaging system, it is permissible to operate an imaging system by remote control provided the imaging system ceases transmission within 10 seconds of the remote switch being released by the operator.

(4) The radiated emissions at or below 960 MHz shall not exceed the emission levels in Section 15.209. The radiated emissions above 960 MHz shall not exceed the following average limits when measured using a resolution bandwidth of 1 MHz:

Frequency in MHz	EIRP in dBm
960-1610	-65.3
1610-1990	-53.3
Above 1990	-51.3

(5) In addition to the radiated emission limits specified in the table in paragraph (c)(4) of this section, emissions from these imaging systems shall not exceed the following average limits when measured using a resolution bandwidth of no less than 1 kHz:

Frequency in MHz	EIRP in dBm
1164-1240	-75.3
1559-1610	-75.3

(d) For equipment operating with f_C and f_M between 1990 MHz and 10600 MHz:

(1) Parties operating this equipment must hold a license issued by the Federal Communications Commission to operate a transmitter in the Public Safety Radio Pool under Part 90 of this chapter. The license may be held by the organization for which the UWB operator works on a paid or volunteer basis.

(2) This equipment may be operated only for law enforcement applications, the providing of emergency services, and necessary training operations.

(3) The radiated emissions at or below 960 MHz shall not exceed the emission levels in Section 15.209 of this chapter. The radiated emissions above 960 MHz shall not exceed the following average limits when measured using a resolution bandwidth of 1 MHz:

Frequency in MHz	EIRP in dBm
960-1610	-46.3
1610-10600	-41.3
Above 10600	-51.3

(4) In addition to the radiated emission limits specified in the paragraph (d)(3) of this section, emissions from these imaging systems shall not exceed the following average limits when measured using a resolution bandwidth of no less than 1 kHz:

Frequency in MHz	EIRP in dBm
1164-1240	-56.3
1559-1610	-56.3

(5) There is a limit on the peak level of the emissions contained within a 50 MHz bandwidth centered on the frequency at which the highest radiated emission occurs, f_M. That limit is 0 dBm EIRP. It is acceptable to employ a different resolution bandwidth, and a correspondingly different peak emission limit, following the procedures described in Section 15.521.

(e) Through-wall imaging systems operating under the provisions of this section shall bear the following or similar statement in a conspicuous location on the device:

> "Operation of this device is restricted to law enforcement, emergency rescue and firefighter personnel. Operation by any other party is a violation of 47 U.S.C. 301 and could subject the operator to serious legal penalties."

4. Section 15.511 is replaced, to read as follows:

Section 15.511 Technical requirements for surveillance systems.

(a) The UWB bandwidth of an imaging system operating under the provisions of this section must be contained between 1990 MHz and 10,600 MHz.

(b) Operation under the provisions of this section is limited to fixed surveillance systems operated by law enforcement, fire or emergency rescue organizations or by manufacturers licensees, petroleum licensees or power licensees as defined in Section 90.7 of this chapter.

(1) Parties operating under the provisions of this section must be eligible for licensing under the provisions of Part 90 of this chapter.

(2) The operation of imaging systems under this section requires coordination, as detailed in Section 15.525.

(c) The radiated emissions at or below 960 MHz from a device operating under the provisions of this section shall not exceed the emission levels in Section 15.209. The radiated emissions above 960 MHz from a device operating under the provisions of this section shall not exceed the following average limits when measured using a resolution bandwidth of 1 MHz:

Frequency in MHz	EIRP in dBm
960-1610	-53.3
1610-1990	-51.3
1990-10600	-41.3
Above 10600	-51.3

(d) In addition to the radiated emission limits specified in the table in paragraph (c) of this section, UWB transmitters operating under the provisions of this section shall not exceed the following average limits when measured using a resolution bandwidth of no less than 1 kHz:

Frequency in MHz	EIRP in dBm
1164-1240	-63.3
1559-1610	-63.3

(e) There is a limit on the peak level of the emissions contained within a 50 MHz bandwidth centered on the frequency at which the highest radiated emission occurs, f_M. That limit is 0 dBm EIRP. It is acceptable to employ a different resolution bandwidth, and a correspondingly different peak emission limit, following the procedures described in Section 15.521.

(f) Imaging systems operating under the provisions of this section shall bear the following or similar statement in a conspicuous location on the device:

> "Operation of this device is restricted to law enforcement, fire and rescue officials, public utilities, and industrial entities. Operation by any other party is a violation of 47 U.S.C. 301 and could subject the operator to serious legal penalties."

5. Section 15.513 is replaced, to read as follows:

Section 15.513 Technical requirements for medical imaging systems.

(a) The UWB bandwidth of an imaging system operating under the provisions of this section must be contained between 3100 MHz and 10,600 MHz.

(b) Operation under the provisions of this section is limited to medical imaging systems used at the direction of, or under the supervision of, a licensed health care practitioner. The operation of imaging systems under this section requires coordination, as detailed in Section 15.525.

(c) A medical imaging system shall contain a manually operated switch that causes the transmitter to cease operation within 10 seconds of being released by the operator. In lieu of a switch located on the imaging system, it is permissible to operate an imaging system by remote control provided the imaging system ceases transmission within 10 seconds of the remote switch being released by the operator.

(d) The radiated emissions at or below 960 MHz from a device operating under the provisions of this section shall not exceed the emission levels in Section 15.209. The radiated emissions above 960 MHz from a device operating under the provisions of this section shall not exceed the following average limits when measured using a resolution bandwidth of 1 MHz:

Frequency in MHz	EIRP in dBm
960-1610	-65.3
1610-1990	-53.3
1990-3100	-51.3
3100-10600	-41.3
Above 10600	-51.3

(e) In addition to the radiated emission limits specified in the table in paragraph (d) of this section, UWB transmitters operating under the provisions of this section shall not exceed the following average limits when measured using a resolution bandwidth of no less than 1 kHz:

Frequency in MHz	EIRP in dBm
1164-1240	-75.3
1559-1610	-75.3

(f) There is a limit on the peak level of the emissions contained within a 50 MHz bandwidth centered on the frequency at which the highest radiated emission occurs, f_M. That limit is 0 dBm EIRP. It is acceptable to employ a different resolution bandwidth, and a correspondingly different peak emission limit, following the procedures described in Section 15.521.

6. Section 15.521 is amended by revising paragraph (c) to read as follows:

Section 15.521 Technical requirements applicable to all UWB devices.

* * * * *

(c) Emissions from digital circuitry used to enable the operation of the UWB transmitter shall comply with the limits in Section 15.209 of this chapter, rather than the limits specified in this subpart, provided it can be clearly demonstrated that those emissions from the UWB device are due solely to emissions from digital circuitry contained within the transmitter and that the emissions are not intended to be radiated from the transmitter's antenna. Emissions from associated digital devices, as defined in Section 15.3(k) of this chapter, *e.g.*, emissions from digital circuitry used to control additional functions or capabilities other than the UWB transmission, are subject to the limits contained in Subpart B of Part 15 of this chapter.

* * * * *

7. Section 15.525 is amended by revising paragraphs (b) and (e), to read as follows:

Section 15.525 Coordination requirements.

* * * * *

(b) The users of UWB imaging devices shall supply operational areas to the FCC Office of Engineering and Technology, which shall coordinate this information with the Federal Government through the National Telecommunications and Information Administration. The information provided by the UWB operator shall include the name, address and other pertinent contact information of the user, the

desired geographical area(s) of operation, and the FCC ID number and other nomenclature of the UWB device. If the imaging device is intended to be used for mobile applications, the geographical area(s) of operation may be the state(s) or county(ies) in which the equipment will be operated. The operator of an imaging system used for fixed operation shall supply a specific geographical location or the address at which the equipment will be operated. This material shall be submitted to the following address:

Frequency Coordination Branch, OET
Federal Communications Commission
445 12th Street, SW
Washington, D.C. 20554

Attn: UWB Coordination

* * * * *

(e) The FCC/NTIA coordination report shall identify those geographical areas within which the operation of an imaging system requires additional coordination or within which the operation of an imaging system is prohibited. If additional coordination is required for operation within specific geographical areas, a local coordination contact will be provided. Except for operation within these designated areas, once the information requested on the UWB imaging system is submitted to the FCC no additional coordination with the FCC is required provided the reported areas of operation do not change. If the area of operation changes, updated information shall be submitted to the FCC following the procedure in paragraph (b) of this section.

(f) * * *

Appendix C
Parties Filing Petitions for Reconsideration of the First Report and Order

1. Aeronautical Radio, Inc. and Air Transport Association of America, Inc. ("ARINC and ATA")
2. American Gas Association and American Public Gas Association ("AGA and APGA")
3. Cingular Wireless LLC ("Cingular")
4. GPR Service Providers Coalition ("GPR Providers")
5. Ground Penetrating Radar Industry Coalition ("GPRIC")
6. Kohler Co. ("Kohler")
7. Multispectral Solutions, Inc. ("MSSI")
8. National Utilities Contractors Association ("NUCA")
9. QUALCOMM Inc. ("Qualcomm")
10. Satellite Industry Association ("SIA")
11. Siemens VDO Automotive AG ("Siemens VDO")
12. Sirius Satellite Radio Inc. and XM Radio Inc. ("Sirius and XM")
13. Sprint Corp. ("Sprint")
14. Time Domain Corporation ("Time Domain")

Comments and Reply Comments Filed in Response to the Petitions for Reconsideration

1. AT&T Wireless Services, Inc. ("AWS")
2. Delphi Automotive Systems Corporation ("Delphi")
3. Ground Penetrating Radar Industry Coalition ("GPRIC")
4. Ground Penetrating Radar Service Providers Coalition ("GPR Providers")
5. Multispectral Solutions, Inc. ("MSSI")
6. QUALCOMM Incorporated ("Qualcomm")
7. Short Range Automotive Radar Frequency Allocation Group ("SARA")
8. Siemens VDO Automotive AG ("Siemens VDO")
9. Sirius Satellite Radio Inc. and XM Radio Inc. ("Sirius and XM")
10. Sprint Corp. ("Sprint")
11. Time Domain Corporation ("Time Domain")
12. U.S. GPS Industry Council ("USGPSIC")
13. Wireless Communications Association International, Inc. ("WCA")
14. XtremeSpectrum, Inc. ("XSI")

Appendix D
Staff Response to Comments Received in Regards to the FCC Office of Engineering and Technology (OET) Technical Research Branch (TRB) Emissions Measurement Report

On October 22, 2002, the FCC Office of Engineering and Technology (OET) released a report documenting the results of a measurement program performed by their Technical Research Branch (TRB).[394] This report ("TRB Report") details a six-month effort to measure existing ambient signal levels at a variety of locations as a first step toward evaluating the underlying assumptions inherent in the derivation of the UWB emission limits in the GPS frequency bands. Upon completion, the TRB report was placed on the open docket (ET Docket No. 98-153) for public review. A 30-day period was established for accepting comments to the report. Eight parties responded by posting comments to the docket during this period. The following list identifies the responding parties: QUALCOMM Incorporated, the United States GPS Industry Council, RF Metrics Corporation, Cingular Wireless LLC, XtremeSpectrum, Inc., Time Domain Corporation, the Ground Penetrating Radar Industry Coalition, and the Public Safety Wireless Network. This Appendix presents TRB staff responses to these comments.

Many of the comments to the TRB measurement report pertain to possible implications to the existing UWB policy associated with the measured data. Since the TRB Report does not contain Policy recommendations, the direct relevance of these comments with respect to the report is not immediately clear. As stated in the TRB Report, the results of these measurements are intended as a first step in collecting data required to make an informed and objective assessment of existing UWB policy. Those comments that pertain to policy issues are not addressed in the responses that follow. Instead, the responses provided herein attempt to address each of the received comments deemed pertinent to the TRB report.

<u>Comments received from QUALCOMM Incorporated ("QUALCOMM")</u>[395]

"*Path Gain Calibration Inconsistent with Block Diagram*"[396]

> QUALCOMM used information from the block diagram in Figure 4-1 to calculate the theoretical gain of the TRB measurement system. The result of their calculation indicates a 5.8 dB discrepancy from the system gain as shown in the calibration plot presented in Appendix A (Figure A-1) of the TRB report. QUALCOMM also inquires as to the type of coaxial cable used in the measurement system.
>
> The information presented in the block diagram provides the manufacturers' specification for each of the individual components used in the measurement system. The companion specifications table (Table 4-1) states the gain of the preamplifiers used in the measurement system as minimum values. Since the gain of an active amplifier is dependent on the operating frequency it cannot be precisely defined by a single value over a broad frequency range. Thus, the gain of an amplifier is typically specified in terms of the minimum value over the specified frequency range.

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394 FCC Project TRB 02-02 Report, *Measured Emissions Data for Use in Evaluating the Ultrawideband (UWB) Emissions Limits in the Frequency Bands Used by the Global Positioning System (GPS)"*, ET Docket No. 98-153, October 22, 2002 (hereinafter "TRB Report").

395 QUALCOMM Incorporated, *Comments of QUALCOMM Incorporated on Report of the Staff of the Office of Engineering and Technology*, ET Docket No. 98-153, November 22, 2002. (hereinafter, "QUALCOMM Comments")

396 *Id*. at pg. 2.

The fact that many of the components used in the measurement system exhibit frequency dependence is precisely why measured calibration curves were provided in the TRB report for each frequency band in which field measurements were performed. It is not surprising that a calculation of the overall system gain based on minimum specifications differs from an actual measurement of the system gain at a discrete frequency. Actual measurements are the only way to accurately determine the overall measurement system characteristics over various discrete frequency ranges.

The measurement system made use of one 25-ft section and three 3-ft sections of Times Microwave Systems LMR-400 flexible shielded coaxial cable with factory installed SMA connectors. The calibration measurements were performed on the measurement system as a whole rather than on each individual component; therefore, data was not collected regarding the frequency-dependent signal attenuation associated with each individual cable.

"*Bandpass Filter Out of Measurement Range*"[397]

QUALCOMM states that the band-pass filter used in the measurement system "*is shown to operate only up to 1500 MHz, whereas, the measurements were performed in the GPS L1 band (1565-1585 MHz).*"[398]

In order to accommodate these measurements, a band-pass filter was necessary to pre-select the frequency band of interest. This was done primarily to protect the first-stage preamplifier from a potential for overload from strong ambient signals originating outside of the frequency band under examination. The ambient signals of particular concern were PCS emissions in the 1900 MHz range, cellular telephone signals in the 800 MHz range, and Aeronautical Radio Navigation Service (ARNS) signals in the 960-1215 MHz range. With respect to the GPS L1 frequency band (1563.42-1587.42 MHz), all of these known ambient signals are at least 300 MHz removed in frequency. Thus the filter requirements necessary to provide the pre-selection for those measurements performed in the GPS L1 frequency band were somewhat relaxed.

The band-pass filter utilized in the TRB measurement system was tunable, thus facilitating measurements over each of the frequency bands examined as a part of the study. In order to examine the GPS L1 frequency band, the filter was used slightly beyond the manufacturer's specification. However, this does not indicate that the filter will not operate. Rather, the effect of operating slightly outside of the specified frequency range is that the specified filter characteristics cannot be assured. In fact, it can be observed from the calibration curve (Figure A-1) that the 3-dB bandwidth is slightly greater than the 50 MHz specification when operated at 1575 MHz. However, since the ambient signals of concern are all well removed from the frequency band under examination, this was not considered a significant limitation.

A slight ripple can be observed at the upper end of the filter pass band, also likely resulting from operating the filter outside of the specified tuning range. However, since the GPS L1 registered frequency band is 24 MHz wide, and the filter has a pass-band greater than 50 MHz, it was possible to tune the filter to accommodate the measurement of the GPS L1 frequency band with the ripple positioned outside of the measurement band. Therefore, this was also determined not to be significant.

397 *Id*. at pg. 3.

398 *Id.*

The measured calibration curves presented in the TRB report provide the most accurate characterization of the band-pass filter over each of the frequency bands examined in the study. Figure A-1 clearly depicts the characteristics of the filter over the GPS L1 frequency band.

"*Measurement System Noise Floor Not Shown*"[399]

QUALCOMM states that they "*tried to calculate the noise floor using 2 methods (1) theoretically using typical values on the block diagram and (2) inferring the noise floor in the GPS L1 band using the calibration plot shown in Figure A-1 of Appendix A in the OET Staff Report…*" [400]

The noise figures associated with the measurement system are expressed in the block diagram and the associated specifications table in terms of the maximum value over the specified frequency range. Maximum values are specified because, like the gain, the noise figure of a component is also dependent on frequency, although the variation is typically less than the gain variation over the specified frequency range. Thus, the result of the QUALCOMM calculation of the "*theoretical noise floor*" (actually the operational sensitivity) of the measurement system, using the noise figure specifications, is fairly representative. This calculation yields a theoretical system sensitivity of –121 dBm.[401]

QUALCOMM then attempts to "*infer the noise floor in the GPS L1 band using the calibration plot shown in Figure A-1 of Appendix A in the OET Staff Report*."[402] We have several reservations with regard to this approach to infer the noise floor from a system calibration curve. The use of a calibration curve to perform this comparison is the likely explanation for the stated disparity. The calibration curves were produced by injecting a signal of known amplitude into the measurement system (less the antenna) while sweeping the injected signal over a frequency range adequate to demonstrate the frequency and amplitude characteristics of the total measurement system. It is not possible to deduce the noise floor of the system from these plots since the influence of the injected signal in the skirts of the band-pass filter cannot be determined. Another likely factor in the stated discrepancy is that QUALCOMM determines the measured power at the band edge of the calibration plot (*i.e.*,-45 dBm/MHz at 1475 MHz) and then applies the system gain (including the antenna) as determined at 1575 MHz. But the overall system gain was not calibrated at 1475 MHz and is likely not the same as at 1575 MHz, since many of the components of the measurement system are frequency-dependent.

A better approach for determining the measurement system operational sensitivity at GPS L1 is to examine one or more of the plots produced from those measurements of the L1 frequency band where no discernable signals were detected (*e.g.*, C-15, C-22, C-29, etc.). Although it is not specifically acknowledged, the QUALCOMM comments indicate that they did in fact examine some of these plots leading to the statement: "*…several of the FCC measurements show values as low as -122 dBm/MHz,…*"[403]

The result of the QUALCOMM calculation of the theoretical operational sensitivity of the measurement system yields a level of -121 dBm/MHz.[404] The measurement system sensitivity as

399 *Id*. at pg. 4.

400 *Id.*

401 *Id*.

402 *Id*.

403 QUALCOMM Comments at pg. 5.

404 QUALCOMM Comments at pg. 4.

determined from the actual measurement plots, rather than the calibration curves, indicates a noise floor of -122 dBm/MHz. This represents a 1 dB inconsistency and is certainly within the range of uncertainty associated with the TRB measurement system, or for that matter, with almost any system designed for performing field measurements of RF signal levels.

"*Questionable Spurious Emissions Plots of Part 15 Devices*"[405]

QUALCOMM states that they have "*…some concerns about the plots of the radiated spurious emissions obtained from some of the Part 15 devices, specifically, the Electric Drill #1 and Electric Hair Dryer #1 measurements*."[406] QUALCOMM maintains that the spectral characteristics are not what they would have expected when averaged over 100 sweeps and questions whether the spectrum analyzer traces may have been produced using the 'Maximum Hold' function of the analyzer.

Irrespective of QUALCOMM engineers' expectations with regard to this data, the plots were indeed generated using the RMS average detector, and integrated over one hundred one-millisecond sweeps, as stated in the report. It was observed that the radiated amplitude peaked and then diminished in the measurement band over the integration period. The plots included in the report depict a "snapshot" of these time-variable peaks over the total integration period. The maximum hold function of the spectrum analyzer was not utilized. If it had been, these plots would likely have resembled the output of a comb generator.

"*Spectrum Analyzer Error Indicator on Screen Capture*"[407]

QUALCOMM questions the presence of the asterisk located in the top right corner of each of the measurement plots provided in the TRB report. They state, "*according to the Agilent 4440 manuals, and upon consultation with Agilent engineers, QUALCOMM understands that this is indicative of an error condition and that the trace may not be valid, in light of the error indicator on all of the spectrum analyzer plots*."[408]

The Agilent user's manual describes the asterisk in the upper right hand corner of the screen as indicative that "*Data on the screen may not match the screen annotation. For example, while analyzer settings are changing or* <u>*when any trace is in view mode*</u>" [409] (underlining added). In these measurements, at least one trace was always stored in the view mode to accommodate the placing of multiple traces on the plots. Therefore, the asterisk quite simply indicates that one or more traces are stored in the view mode. It does not indicate an error condition. If the analyzer had actually detected an error condition an accompanying text message would have been prominently displayed on the screen. These messages would also appear on the screen capture plots provided in the report.

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405 QUALCOMM Comments at pg. 5.

406 *Id.*

407 QUALCOMM Comments at pg. 6.

408 *Id.*

409 Agilent Technologies, "*Agilent PSA Series Spectrum Analyzers Instrument Messages and Functional Tests,*" May 2002, Status Messages, p 38.

"*Indoor Ambient Noise Plots*"[410]

In this comment, QUALCOMM discloses that they have conducted their own measurements, similar to the indoor measurements performed by TRB, and "*found all sites to have emissions less than or equal to –117.5 dBm.*"[411]

The data provided in the TRB report shows a variation in the observed emission levels among different indoor locations. Based on the data provided from the QUALCOMM measurements, their results seem to fall within this range of values. TRB cannot offer significant comment with respect to the measurements performed by QUALCOMM as there is insufficient information presented to accommodate any substantive assessment.

Comments received from the United States GPS Industry Council ("USGPSIC")[412]

The following paragraphs respond to those comments provided in the USGPSIC submission that are deemed relative to the subject document. While we appreciate those comments that were apparently provided for informational purposes, we have not responded to each herein.

"*The report exhibits bias in the use of the descriptor "extremely conservative emissions limits" when referring to the UWB emission limits defined to protect the GPS service using frequency bands allocated to safety-of-life use. Furthermore, the protection is for the European system Galileo as well as for GPS.*"[413]

The descriptor "extremely conservative emissions limits" used in the subject report directly reflects the language contained in the UWB Report and Order (R&O). No bias was intended in repeating this language, and certainly none was exhibited in the measurement effort.

The USGPSIC assertion that *"the protection is for the European system Galileo as well as for GPS"* is mistaken. No consideration was given in this proceeding to the potential impact of UWB emissions to the developing European Union (EU) Radio Navigation Satellite Service (RNSS) system known as Galileo.

"*Many GPS receivers process bandwidths greater than 16 MHz – up to 20 MHz, especially those used in aviation and precision applications (ground and air).*"[414]

We acknowledge that there are GPS receivers that process greater than 16 MHz of the GPS L1 signal; however, we are skeptical that there are "many" of these in operation. Nonetheless, the GPS receivers assumed in the operational scenario described in the report (*i.e.*, the E-911 scenario) do not use these types of receivers. Based on discussions with Qualcomm, its assisted GPS receivers used in E-911 applications process only 1 to 2 MHz of the GPS L1 signal. We note that the measurements performed by TRB and documented in the subject report examine the entire registered bandwidth (24 MHz) associated with each of the GPS center frequencies (L1, L2, and L5).

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410 QUALCOMM Comments at pg. 7.

411 *Id.*

412 United States GPS Industry Council, Comments on the FCC TRB Report, ET Docket No. 98-153, November 22, 2002. (hereinafter "USGSIC Comments")

413 USGPSIC Comments at pg. C-1.

414 *Id*.

"*It is also important to note that UWB emissions impact the GPS P-code, and thus military users, as much as they impact civil C/A-code users. The additional spreading of the higher chipping-rate P code does not increase the processing gain against wideband noise.*"[415]

Neither empirical nor analytical data were provided to the record established in the UWB proceeding to support the claim that GPS P-code (military) receivers are as susceptible to UWB emissions as are C/A-code receivers. We acknowledge that the impact to the noise floor will be comparable; however, we are skeptical that the actual operational impact to a P/Y-code GPS receiver will be the same as to a civil C/A-code receiver. For example, the spectral line interference potential demonstrated in the NTIA testing of GPS receivers revealed that as a result of the relatively short (1 millisecond) length of the codes associated with the C/A signal (*i.e.*, the Gold codes), a spectral line produced by an unmodulated UWB signal has a potential for alignment with a dominant C/A-code line, resulting in an observable degradation to receiver performance.[416] However, the P-code signal is a significantly longer code producing an essentially continuous signal. Thus the dominance of any single spectral line in the P-code is considerably reduced. Although not specifically examined as a part of this proceeding, the potential for spectral line interference to the P-code signal is expected to be significantly less than it is to the C/A-code signal. This was demonstrated in the NTIA measurements for the semi-codeless GPS receiver architecture.

"*The fact that the actual GPS signal levels are known to be 7-10 dB greater than the minimum level is overstated – more like 3 to 5 dB. The Aerospace Corporation has written ION papers documenting this fact. <u>However, the DoD will not guarantee those higher levels, so the GPS safety-of-life community can only rely on the -130 dBm level</u>*."[417]

No data was provided to the record established in the UWB proceeding to validate the actual GPS signal levels experienced by a user. Rather, the analyses presented to the record by GPS interests utilized the minimum specified power of -130 dBm. Other interests claimed that the levels are actually much higher. However, this discrepancy has little relevance to the results presented in the TRB report since the report contains no analyses utilizing the GPS signal levels.

It is recognized that the -130 dBm level is the minimum GPS signal level guaranteed to the civil user community (irrespective of whether or not the application involves safety-of-life). The operational scenario considered in the subject report involved the use of enhanced GPS to facilitate E-911 applications. It is noted that this is <u>not</u> a recognized "safety-of-life" application as usually applied to interference analyses. The safety-of-life designation, and the additional protection afforded, is reserved for those applications where a degradation or loss of signal could result in a catastrophic public safety disaster. For example, the use of GPS in aviation applications, such as the precision approach and landing of aircraft, are designated as safety-of-life applications since the loss of the navigation information necessary to perform this operation, even for a brief period, could result in a significant loss of life and property. In contrast, when using GPS to augment an emergency telephone call, a brief degradation or loss of signal is not likely to result in a public safety disaster.

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415 *Id*. at pg. C-2.

416 NTIA Special Publication 01-45, *Assessment of Compatibility between Ultrawideband (UWB) Systems and Global Positioning System (GPS) Receivers*, U.S. Department of Commerce, February 2001.

417 USGPSIC Comments at pg. C-2.

"*With respect to the modernized L2 signal, it may be the C/A-code in the beginning, but will be the new L2C codes eventually, maybe earlier. This new signal is intended to be used by the E911 application once it is available on most of the satellites. Thus, this band must be protected, even though it is not used for aviation (except at protected ATC sites for WAAS using the P/Y code in a semi-codeless manner, but eventually using the L2C code)*."[418]

Only limited data was presented to the UWB record regarding the potential impact to GPS operations on L2. This data was constrained to the results of the NTIA testing of a semi-codeless GPS receiver using the P-code signal on L2, which is not comparable to a civil L2 (or L2C) receiver. Also, no information was presented to indicate any future plans for E-911 on GPS L2C, although the E-911 providers were active participants in the process. The possible use of the L2C signal for E-911 has been mentioned in the literature.[419] This E-911 application would be facilitated by the inclusion in the L2 signal of a signal containing the navigation data in conjunction with a signal without the navigation data.

The existing UWB rules provide equivalent protection for GPS operations on L2 and L1. However, once the civil signal becomes completely defined for L2, the protection criteria should be re-examined considering not only the signal structure (C/A or L2C) but also other factors such as possible signal redundancy among three available GPS civil signals.[420]

"*Galileo also plans two signals at and near the L5 signal frequency. These signals must also be protected. It is not appropriate for UWB to overlay signals allocated to entities outside its jurisdiction*."[421]

No information was submitted to the UWB proceeding regarding Galileo operations or interference protection requirements. While the emission masks developed by this rulemaking will also provide a level of interference protection to future Galileo receivers, this was a coincidental outcome. No consideration was given in this proceeding to the interference potential from UWB emissions to developing non-U.S. systems, including Galileo.

"*It is not exactly true that the L5 signal is less susceptible to both noise-like and spectral line interference than the existing L1 signal for two reasons. First of all, as it is for the P-code, the longer code signal is just as susceptible to broadband noise-like interference (like UWB) as the C/A code is. Second, the propagation loss at L5 is 2.54 dB less than it is at L1, so more of the UWB emission power will be observed at L5. This is also true for other interference at L5*."[422]

No empirical or analytical data was submitted in the UWB proceeding to validate this statement. This data was not made available during the proceeding primarily due to the fact that the GPS L5 signal structure was in its conceptual stage and L5 receivers were not yet available for testing. However, we believe that the longer code that has been adopted for use on L5 will reduce the potential for interference from spectral line interactions for similar reasons as those discussed previously with respect to the P-code. In addition, other factors that were not specifically

418 *Id*.

419 *GPS World*, September 2001, at pg. 24.

420 Multiple GPS signals can be used simultaneously to increase the accuracy of the GPS navigation solution.

421 *Id*.

422 *Id*.

considered in this proceeding, but should be considered in future efforts to determine the actual interference potential to GPS L5 receivers, include the increased GPS signal power planned for L5, the pulse-blanking circuitry to be implemented in the receivers, the signal redundancy associated with three available civil GPS signals, and the forward error correction being implemented. When these factors are considered in an interference analysis, we believe it will show GPS L5 receivers to be less susceptible to both spectral line and noise-like interference, irrespective of the emission source. We note that there is considerable evidence to support this position within the Public Domain. For example, a report by the Volpe National Transportation Systems Center, prepared under contract to the U.S. Department of Transportation in response to Presidential Decision Directive 63, concluded the following in this regard: "*The GPS Modernization Program is expected to provide a substantial reduction in the threat from unintentional interference*" and "*Higher GPS signal power, a C/A (or replacement civil, R/C) code on L2 and a more robust civil code on L5, all combine to reduce greatly the susceptibility of civil applications of GPS to unintentional interference*."[423]

"*The equation for N_0 in the FCC TRB report is not correct for the noise floor. The equation only describes "receiver" noise – doesn't include ambient source noise*."[424] This comment continues over seven paragraphs, wherein the intent appears to be to offer a theory to explain the elevated noise levels observed at the indoor measurement locations as compared with those levels observed at the outdoor measurement sites. The basis for this theory is a difference in source temperature between indoor and outdoor measurement locations. The comment is not expressed in its entirety herein, but a response is provided with respect to the assumptions offered in the development of this theory.

The equation presented in the TRB report is clearly defined as representing the thermal noise density of a typical GPS receiver.[425] It was never intended to include ambient source noise. Rather, the objective of the measurement effort was to determine the ambient source noise empirically rather than analytically.

A variation in the absolute temperature between the outdoor and indoor measurement sites is acknowledged to exist; however, this differential is not as extreme as suggested in these comments. The measurement antenna used in collecting the data was never pointed at the sky as assumed in the development of the USGPSIC theory. Instead, the antenna was pointed in a horizontal direction relative to the measurement site with a height of approximately 2 meters above local terrain elevation. With this orientation ground clutter was indeed a factor, and thus was not eliminated as assumed in the development of this theory.

Comments received by RF Metrics Corporation ("RFM")[426]

"*Many of the measurement results do not agree with the stated measurement system performance parameters*."[427]

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423 John A. Volpe National Transportation Systems Center, *Vulnerability Assessment of the Transportation Infrastructure Relying on the Global Positioning System*, Final Report, August 29, 2001, p. 35.

424 USGPSIC Comments @ C-3.

425 TRB Report at pg. 9.

426 RF Metrics Corporation, *Comments of RF Metrics Corporation on Report of the Staff of the Office of Engineering and Technology Project 02-02*, ET Docket No. 98-153, November 22, 2002. (hereinafter "RFM Comments")

427 *Id*. at pg. 2.

RFM used the data presented in the block diagram (Figure 4-1) and the companion table of specifications (Table 4-1) presented in the TRB Report to perform "*a cascaded gain and noise figure analysis neglecting cable losses*." The results indicate *"...a system noise figure of 4.3 dB for system A, 6.1 dB for system B, and system gains (excluding the antenna) of 59 dB and 56 dB respectively*." RFM states that these results "*differ significantly from the measured system gains*."[428]

The results of the computer-aided analysis of these parameters are presented in Appendix A of the RFM submission. Since the source code for the model is not provided, a substantive assessment of its accuracy cannot be performed. However, we do note several potential factors that may have led to the stated discrepancy.

In the calculation of the overall system noise figure we have some concerns regarding the input to the computer model. In particular, the measurement system is modeled as a seven-stage cascaded network; however, the TRB measurement system utilized only three active stages. Additionally, noise figure values of 1 dB and 10 dB are shown as inputs to represent the band-pass filter and the in-line attenuator, respectively. These are passive components in the TRB measurement system and thus have no associated noise figure. Finally, a noise figure of 60 dB is input for the spectrum analyzer. No explanation is provided to support this value and in fact, the spectrum analyzer would be a significantly limited piece of test equipment with a noise figure of this magnitude. We suspect these factors to be the primary cause for the stated discrepancies with respect to the system noise figure.

RFM used the specification values for the individual components in the measurement system to calculate the overall system gain. These specifications represent the minimum gain values of the preamplifiers used in the measurement system. Since the gain of an active amplifier is dependent on the operating frequency it cannot be precisely defined by a single value over a broad frequency range. Thus, the gain of an amplifier is typically specified in terms of the minimum value over a defined frequency range.

The fact that many of the components used in the measurement system exhibit frequency dependence is precisely why measured calibration curves were provided in the TRB report for each frequency band for which field measurements were performed. It is not surprising that a calculation of the overall system gain based on minimum specifications differs from an actual measurement of the system gain at a discrete frequency. Actual measurements are the only way to accurately determine the overall measurement system characteristics over various discrete frequency ranges.

"*The system as described in the report suffers from significant vulnerability that could produce spurious emissions within the system itself. Some measurements show potential evidence of such spurious emissions*."[429]

The TRB Staff was cognizant of the vulnerabilities associated with the measurement system design. This is an unfortunate consequence of the extraordinary requirement to detect radiated emissions to the extremely low amplitudes dictated by the UWB emission limits in the frequency bands examined. However, every precaution was taken to ensure the integrity of the

428 *Id*.

429 RFM Comments at pg. 2.

measurement system in the performance of this project. This included the method suggested by RFM,[430] which is also described in Appendix B of the TRB Report.[431]

RFM states that their calculations indicate the second-stage preamplifier in the TRB measurement system is "*particularly vulnerable to intermodulation and gain compression in the reported design. For system A, a calculation shows that the system will incur 1 dB of gain compression at input signal levels from -51 dBm to -47 dBm. For system B the compression point is between -50 dBm to -46 dBm, depending on frequency*."[432] We note that there were no measurement locations identified where the ambient emission levels in the GPS L1 or L2 frequency bands even remotely approached the maximum input levels calculated by RFM. High amplitude emissions (relatively speaking) were only encountered in those measurements performed within the 960-1188 MHz band, and then only at a few limited locations, in particular the airport sites. Even at these sites, most of the emissions were well below the amplitude levels indicated above. In those few cases where emissions were observed at levels great enough to pose a potential for system overload, tests were performed to verify the measurement system linearity as noted previously. Where necessary, the measurement system was desensitized through the addition of in-line attenuation. It is recognized that an alternative approach would have been to remove the second stage pre-amplifier from the measurement system in these cases, but retaining consistency with regard to the measurement system was deemed more significant. This explanation provides the justification for the inclusion of "*both 65 dB of gain and 50 dB of attenuation in the signal path*" as noted in the RFM comments.[433] However, we note that this configuration was utilized only for a very limited number of the measurements performed.

Comments received by Cingular Wireless LLC ("Cingular")[434]

"*There was apparently no attempt to make the studies systematic or representative. All of the locations selected for ambient noise studies were in a single geographic area, around Washington and Baltimore, and do not include many types of environments where assisted GPS is likely to be used in connection with wireless E-911 calls, such as homes or highways.*"[435]

As noted in the TRB Report, this project was intended as a "first step" toward collecting the data necessary to perform an objective re-evaluation of the UWB emission limits. The measurements were indeed all performed at locations in the Baltimore-Washington area, primarily to facilitate a maximum use of the available measurement time by limiting the logistical complications associated with travel and long-distance coordination. The premise was that many of the locations (*e.g.*, office buildings, factory locations, airports, etc.) are fairly representative regardless of their particular geographic location. However, we do concede that the set of measurement locations is somewhat limited in scope. The compilation of a similar data set that would be universally accepted as statistically representative would likely require a considerably more extensive effort to collect. Rather, this project was designed to perform a "spot check" of

430 *Id*. at 5.

431 TRB Report at pg. B-1.

432 RFM Comments at pg. 3.

433 *Id*. at pg. 3.

434 Cingular Wireless LLC, *Comments on Emissions Report*, ET Docket No. 98-153, November 22, 2002. (hereinafter "Cingular Comments")

435 *Id*. at pg. 3.

pre-existing (*i.e.*, non-UWB) emissions that would be encountered by a GPS receiver when attempting to operate at the reported location within a time frame coincident with that over which the measurements were performed. The intent was to assess some of the underlying assumptions inherent in the link-budget derivation of the UWB emission limits applicable to the GPS frequency bands.

"*The report does not indicate whether the cause of these noise levels was traced or whether the sources of the noise were in compliance with applicable licensing or Part 15 requirements*."[436]

In fact, the TRB report clearly states that no attempt was made to determine each and every emission source contributing to the measured noise levels.[437] To attempt to do so would represent a monumental undertaking. Instead, the report provides the likely emission sources where possible, but no effort was made to verify or specifically locate and measure each emission source for compliance to the applicable regulations. As described above, the intent was to observe the existing emission levels that would be experienced by a GPS receiver at the measurement location during the time the measurements were performed. The amplitude and signal characteristics of the total noise present at its input will determine the impact to a GPS receiver. The total noise was the parameter of interest recorded at each of the measurement locations.

"*The study is no more than a snapshot of what is occurring in RF spectrum at a limited number of locations on a certain date and time*."[438]

This fact is recognized; however, as stated previously, this was the intent of the TRB measurement program.

Comments received by XtremeSpectrum, Inc., Time Domain Corporation, the Ground Penetrating Radar Industry Coalition, and the Public Safety Wireless Network[439, 440, 441, 442]

The comments received from these parties have each been reviewed in their entirety; however, since the issues raised within pertain solely to interpretations and/or recommendations related to existing UWB policy, rather than to the content of the TRB Report, they are not specifically addressed herein.

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436 *Id*. at pg. 5.

437 TRB Report at pg. 15.

438 Cingular Comments at pg. 5.

439 XtremeSpectrum, Inc., *Comments of XtremeSpectrum, Inc.*, ET Docket No. 98-153, November 22, 2002.

440 Time Domain Corporation, *Comments of Time Domain Corporation*, ET Docket No. 98-153, November 22, 2002,

441 Ground Penetrating Radar Industry Coalition, *Comments of the Ground Penetrating Radar Industry Coalition*, ET Docket No. 98-153, November 22, 2002.

442 Public Safety Wireless Network, *Comments to the Federal Communications Commission Report, Measured Emissions Data for Use in Evaluating the Ultra-Wideband (UWB) Emissions Limits in the Frequency Bands Used by the Global Positioning System (GPS)*, ET Docket No. 98-153, November 22, 2002.