Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, DC 20554

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

COMMENTS OF THE BOEING COMPANY

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The Boeing Company ("Boeing"), pursuant to Sections 1.415 and 1.419 of the Commission's Rules, 47 C.F.R. §§ 1.415 & 1.419, hereby comments in response to the above referenced Notice of Proposed Rule Making ("*NPRM*").

I. INTRODUCTORY SUMMARY

Boeing has a wide breadth of interests in the Commission's consideration of radio transmission devices utilizing ultra-wideband ("UWB") technologies. As the world's largest manufacturer of commercial and governmental aircraft, Boeing and its customers are major users of radio spectrum that could be subject to interference from UWB devices. For example, Boeing relies heavily on private land mobile radio ("PLMR") networks operating below 1 GHz for plant communications and emergency response systems.[1] Critical to Boeing and its commercial and military airplane manufacturing is

[1] Boeing uses its private radio licenses for a number of different purposes ranging from compliance with aeronautical and industrial regulations; communications with personnel in confined and isolated areas; deployment of fire, security and emergency services; research and development; and, robotics to the control and monitoring of production; material handling; machine programming; inventory management; and, transportation. In all of these applications, Boeing uses its private radio systems to provide internal communications that protect the safety of life, health and property, and enhance the productivity of its manufacturing operations.

aeronautical telemetry for aircraft flight tests in the 1435-1525 MHz and 2360-2385 MHz bands. Also important to Boeing is its large investment in numerous wireless LAN systems operating in the 2.400-2.4835 GHz (ISM) band utilized for the transmission of production data within the office and factory areas.[2]

Boeing's interests in this proceeding also stem from its participation in aeronautical safety and regulatory organizations that coordinate the use of radio spectrum for aviation Communication, Navigation and Surveillance ("CNS") systems, which are critical to the safe and efficient operation of the global aviation industry. Boeing is also a global leader in the design, construction and launch of satellites and other space systems.[3] The protection of GPS and each of the safety and navigation services utilized by the aviation industry, as well as safety of life services in other bands, must be a primary focus of this proceeding.

While Boeing has significant concerns about the interference potential of UWB technologies, it is also very interested in the potential beneficial applications of UWB that may not be possible using conventional transmission/modulation techniques. Boeing is currently involved in contracts that include the evaluation of UWB technologies for new government applications. Boeing also sees many non-governmental applications for UWB that may have a tremendous public benefit, such as structural inspections,

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[2] Future plans envision use of 5GHz spectrum to support higher data rate transmissions.

[3] Boeing helped revolutionized precision navigation by building the first 40 Global Positioning System ("GPS") satellites and has been selected by the U.S. Air Force to develop the next generation (block IIF) GPS satellites. Following the pending acquisition of Hughes Space and Communications, Boeing will also be the largest satellite manufacturer in the world.

emergency response (see through walls), and proximity alarms. Boeing intends to continue to participate in UWB testing and experimentation, with the caveat that practical applications of UWB technologies must be authorized only to the extent that they do not result in harmful interference to existing spectrum uses, particularly those that are necessary for the safety of life and property.

Recognizing Boeing's broad and carefully balanced interests in UWB technologies, Boeing herein makes the following recommendations and comments:

- Boeing supports the development and implementation of "new technologies" but, in light of the critical importance and delicate nature of many safety related spectrum uses, the Commission must ensure that any use of UWB technology does not cause harmful interference to existing spectrum users such as GPS.

- The Commission should not adopt any rules (interim or final) governing UWB technologies until additional technical studies are completed and analyzed through a process of public comment. Furthermore, the Commission should acknowledge that its October 1, 2000 date for the completion and submission of studies is premature.

- In the interim, low power/low Pulse Repetition Frequency ("PRF") UWB system applicants that demonstrate that their equipment can operate without resulting in harmful interference should continue to be assessed and, if appropriate, authorized by the Commission through the issuance of temporary waivers on a case-by-case basis.

- In considering whether to eventually authorize the general use of UWB technologies, the Commission should separately consider:

  1) low PRF UWB applications that are technically not feasible using conventional transmission/modulation techniques (such as Ground Penetrating Radar ("GPR")), and

  2) moderate to high PRF UWB applications that could better be accommodated in discrete spectrum allocations using conventional modulation

  It might be appropriate to eventually authorize low PRF UWB devices, but probably not moderate to high PRF UWB devices until significant further study and demonstrated performance has been assessed.

- If the Commission does authorize the use of low power/low PRF UWB devices, it should do so on a secondary basis through a process of blanket licensing pursuant to a new part to Title 47 of the Code of Federal Regulations (and not pursuant to Part 15 of the Commission's rules).

II. THE COMMISSION SHOULD AUTHORIZE THE USE OF UWB TECHNOLOGIES ONLY AFTER ADDITIONAL STUDIES ARE COMPLETED AND ALSO CONDITIONED ON THE STRICT AVOIDANCE OF HARMFUL INTERFERENCE TO EXISTING SERVICES.

The Commission deserves praise for its initiative in establishing on its own motion a proceeding on UWB technologies in 1998, at a time when private industry was still just beginning to document the practical and potentially beneficial applications that could be provided through the use of this technology. If the Commission attempts to complete this rule making process too quickly, however, the public interest benefits that could result from the Commission's initiation of this proceeding may be lost. The Commission should also avoid reaching preliminary conclusions (which might unduly influence the final outcome of this proceeding) without the benefit of a thorough examination of additional interference studies.[4]

As the Commission acknowledges in the *NPRM*, further studies are being conducted in a variety of public and private forums to ascertain the interference characteristics of UWB applications. The Commission indicated in the *NPRM* that it would allow a "reasonable period of time for submittal of test results into the record in this proceeding and will provide an opportunity for public comment on the test results before reaching any conclusions."[5] The Commission then indicated that parties are

[4] *Contra NPRM*, ¶ 1 (tentatively concluding that "UWB devices appear to be able to operate on spectrum already occupied by existing radio services without causing interference").

[5] *NPRM*, ¶ 7.

encouraged to submit test results by October 30, 2000,[6] clearly a premature deadline for the completion of the types of studies that would be prudent in order to move forward with UWB proposals.

A significant period must also be made available to analyze and comment on the results of tests being conducted on UWB applications. Such a process necessitates developing and validating models that represent the operation of UWB technology and understanding the physics of the interaction of UWB with the incumbents (aviation and others) in order to establish a basis for the potential acceptance of UWB technology.

In other words, not only are additional facts and data needed, but also theories, models and understanding of the technology – all of which will take time not only to discover but also to disseminate and digest. Boeing has considered, but rejected the idea of, asking for an extension to the *NPRM* comment period.[7] It is not the comment period, but the entire rule making process that needs extension. Considering the significant risks and the technical complexities, at least six months to a year of additional study and testing is required. Until more analysis has been done, the FCC should refrain from adopting any rules (interim or otherwise) and instead continue to authorize experimental uses of very low power/low PRF UWB devices solely on a case-by-case basis as warranted.

Boeing's concern about UWB technologies stems, first, from the simple fact that with increased power and PRFs, UWB devices in the aggregate have the potential to

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[6] *Id.*, ¶ 31.

[7] In this respect, Boeing supports the comments of the GPS Industry Council in asking for a delay.

significantly raise the noise floor across multiple spectrum bands. Second, that this increase in the noise floor could result in interference to existing services, including critically important safety-related CNS services (including GPS), Flight Test Telemetry, and various satellite services. There are indications that the effect of the aggregate of UWB signals does more than simply increase the noise floor and Boeing is concerned about the true impact of multiple UWB devices using high PRFs. For example, the preliminary DOT/Stanford testing has shown that some UWB signal structures can interfere with GPS signal reception at a much lower relative power than broadband noise.[8]

As the Commission acknowledges in the *NPRM*, the protection of safety services such as GPS[9] is "vitally important."[10] The global community at large has adopted GPS and integrated GPS services into the basic communications and transportation infrastructure around the world.[11] The economic implications of widespread GPS interference are potentially staggering. Boeing will be unequivocal about its support for

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[8] *See* Dr. Per Enge et al., *UWB Interference Test Preliminary Results*, presentation to RTCA WG 6 (Aug. 4, 2000).

[9] GPS is important for safety of life, for the well-being and military security of this country, and for the global economy. Boeing builds numerous systems for the government that are critically dependent on GPS for their performance. These systems often involve a critical component of safety for human life — e.g., survival radios to rescue downed pilots, safe navigation and operation of military aircraft and even minimization of collateral damage and casualties from GPS-guided weapons.

[10] *NPRM*, ¶ 29.

[11] The global aviation industry is also adopting GPS as its primary navigational tool. New aviation related systems, such as space-based CNS/ATM (air traffic management) initiatives, WAAS (wide area augmentation system), and future satellite communications systems, will depend on GPS.

GPS: quite simply, Boeing feels that UWB must not interfere with GPS at all even if it requires severe limitations on the acceptable implementation of UWB technology.

Protecting commercial and government GPS applications is obviously essential. Unfortunately, ensuring that protection is far from simple because identifying and correcting interfering anomalies can be difficult and unpredictable.[12] Boeing is concerned that the general use of UWB technology could exacerbate this problem. Therefore, efforts must be made to thoroughly identify the interference characteristics of UWB equipment so they can be replicated in a laboratory environment. UWB sponsors should be willing to support fully such research and adapt their proposed systems as necessary to respond to problems. Given the possibility of such occurrences, the Commission must be prepared to establish an appropriate expedited interference resolution process for those instances where harmful interference is suspected to be caused by UWB devices.

Furthermore, the Commission should be cautious and refrain from accepting the popular notions that: (1) GPS is the most vulnerable spectrum use implicated in this proceeding and (2) if it can be shown that UWB does not interfere with GPS, then all other systems will likely not suffer from interference. There is in fact no hard evidence

[12] For example, it has been well documented that the thirteen harmonic from the 121 MHz and 131 MHz VHF bands can interfere with GPS signal reception if a VHF transmitter is improperly shielded or the antenna is improperly placed on the airframe of an aircraft. This interference is particularly hard to pin down, however, since it can be generated by interaction with so-called nearby inert elements (e.g., nonparticipating components of other radios, such as an Emergency Locator Transmitter ("ELT") antenna or a receiver front end). The documentation of this interference condition is extremely difficult and such interference events might have remained unexplained phenomena but for some fortuitous observations in a contained environment.

that this is the case. The susceptibility of any receiver equipment to UWB interference depends on many things including the signal structure of the UWB interfering source, the signal structure of the "victim" signal, and the physical properties of the antenna and front end electronics of the victim receiver. Unfortunately, most of the systems in use today are not extremely well characterized with respect to their interference susceptibility.

In fact, the interference susceptibility of GPS receivers is probably understood better than virtually any other system currently in use due to the scrutiny with which the potential for GPS interference from MSS has been evaluated over the past few years.[13] The preliminary, and thus far inadequate, studies of UWB interference to GPS indicate that the impact of UWB signals depends greatly on the specific structure of the UWB interference and on the structure of the victim signal. It is possible that there are non-GPS systems that would be more susceptible to some types of UWB signals than would GPS. Therefore, the potential for interference from UWB to every system should be considered in the light of the specific nature of the system signal structures as well as the common receiver and antenna designs deployed.[14]

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[13] *See, e.g., CPM Report on Technical, Operational and Regulatory/Procedural Matters to be Considered by the 2000 World Radiocommunication Conference,* International Telecommunication Union, Radiocommunication Sector, §§ 2.2-2.2.1.4 (Geneva, 1999) (discussing the signal characteristics of GPS and its susceptibility to interference from the mobile-satellite service).

[14] Furthermore, simply because the FCC does not hear from an interest group regarding incumbent spectrum uses in every band does not mean UWB applications will not cause users of that band a problem. It only means they do not have a spokesperson or that users of the band are unaware of the potential for harmful interference and are trusting that the Commission will "protect" their existing licenses.

The importance of further study is underscored by the significant number of safety services that operate in the bands often with delicate link margins at or near the noise floor.[15] In the aviation industry alone, such services include, but are not limited to, devices such as Radio Altimeters,[16] aircraft DME (Distance Measuring Equipment) systems, SATCOM (Satellite Communications), MLS (Microwave Landing System), ILS (Instrument Landing System), VOR (VHF Omnidirectional Range), ADF (Automatic Direction Finder), HF (High Frequency) and VHF (Very High Frequency) communications systems, TCAS (Traffic Alert and Collision Avoidance System), Mode S (Mode Select), ASR (Airport Surveillance Radar), and weather radar.[17]

To ensure that there are no unforeseen anomalies between UWB devices and these aviation critical systems, Boeing encourages the Commission to assess UWB devices in a manner similar to the SIMOP (Simultaneous Operation) analysis, which is

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[15] In this respect, the Commission should not rely on Section 15.205 of the Commission's rules (the "restricted bands" list) for a complete accounting of the critical public safety services that might suffer interference from UWB devices. The aviation industry uses numerous spectrum bands for essential public safety services that are not included in the restricted bands list.

[16] Radio Altimeters at 4.3 GHz are an example of the sensitive nature of these aviation communication and navigation links. A radio altimeter is a part of the autoland system in commercial transport aircraft and is considered to be a critical system. The radio altimeters uses directional antennas pointed directly beneath the aircraft and are used during landing approach from 4000 ft AGL through touchdown. A significant potential exists for interference from UWB devices at short range during fly over events as aircraft pass over industrial, mining and construction and commercial developments in the approach for landing at airport facilities.

[17] For specific information on the bands and types of services for these aviation systems, see RTCA SC-185 Document, RTCA/DO-237, Aeronautical Spectrum Planning for 1997-2010, Table 3-1 "Frequency Bands Supporting Current Aeronautical Functions" (1/27/1997)

required for Federal Aviation Administration certification of avionics equipment on board an aircraft. A SIMOP analysis takes into account not only the prime frequencies used, but also all significant harmonics and products generated by the mixing of the sums and differences created by the multiple transmitters on board an aircraft.[18]

The Commission should also employ the same initiative that it used to initiate this proceeding and direct that initiative toward coordinating and reviewing the numerous interference studies that will be needed to ensure that UWB technologies can be used to further the public interest without endangering the safety of the general public.

III. THE COMMISSION SHOULD BIFURCATE ITS CONSIDERATION OF WHETHER THE PUBLIC INTEREST WOULD BE SERVED BY THE AUTHORIZATION OF UWB TECHNOLOGIES.

Obviously, the FCC should adopt policies that encourage the efficient use of spectrum.[19] Boeing acknowledges that UWB technologies have the potential to enable new practical applications that may have significant public interest benefits to consumers. As discussed in the previous section, however, the potential public interest benefits of UWB technologies must be subordinate until the potential for interference to existing

[18] To this end, Boeing intends to support its airline and government customers through active participation in relevant tests.

[19] The record shows that Boeing supports the efficient use of spectrum use by all spectrum users. *See, e.g.*, Boeing's *Ex Parte* Presentation to the FCC, PR Doc. No. 92-235, "Frequency Spectrum Issues", at 16 (filed Sept. 25, 1995), Comments of The Boeing Co., PR Docket No. 92-235, at 3 (filed Nov. 20, 1995), Reply Comments of The Boeing Co., PR Docket No. 92-235, at ii (filed Jan. 11, 1996), and Boeing's *Ex Parte* Presentation to the FCC, "Frequency Spectrum Issues – Inefficiency License Fees" (filed Feb. 21, 1997); *see also* Boeing Ex Parte Filing, WT Doc 99-87, DA-2206, May 21, 1999 in presentations titled "Inefficiency License Fees" (at multiple pages) and "Frequency Spectrum Issues" (at page 14, 18) and Comments of The Boeing Company, WT Docket 99-87 (filed August 2, 1999).

spectrum uses, particularly those that include a public safety component, is understood and resolved. In attempting to address this conflict, Boeing believes that the Commission could best serve the public interest by bifurcating its consideration of UWB applications by separately considering:

- very low power/low PRF UWB applications that are technically infeasible using conventional transmission/modulation techniques (such as GPR) and
- moderate to high power/PRF UWB applications that are already feasible through the use of conventional transmission/modulation techniques in discrete spectrum allocations (such as wireless LANs).

Subject to the outcome of further analysis and testing, it may be spectrally efficient to authorize the limited use of certain very low power/low PRF UWB technologies to provide services that cannot be provided using conventional transmission/modulation techniques. For example, applications such as GPR can only be provided effectively using an ultra wideband signal structure and, as a result, the availability of this potentially beneficial service to public safety services and geologists is contingent on its authorization by the FCC.

In stark contrast, wireless communication services such as LANs are already commercially available to consumers using discrete spectrum allocations on both a licensed and unlicensed basis. The introduction of UWB-based wireless communication systems would not expand the types of services available to the public. It would simply provide a new, but not necessarily more spectrally efficient, means to provide an existing consumer service.

Choice of UWB technology strictly for ease of licensing or to minimize the expense of the user equipment may not be in the public interest. Other more spectrally efficient technologies may be able to provide equivalent service without the potential for

interference inherent of the UWB technology due to the wide bandwidth used. It is Boeing's concern that if the UWB signal strategy becomes attractive because of 1) ease of licensing (or via Part 15 with no licensing at all), or 2) the potential for very low cost receiver equipment, then the possibility of aggregate spectral interference will become much larger and effectively uncontrollable.

UWB equipment by necessity requires very wide bandwidth front end. Consequently, the amount of ambient noise and receiver thermal noise in the system is large. In order to achieve high Signal to Noise (S/N) ratios typically required for reliable data transmission, the integration of many UWB pulses per bit is required. If high effective data rates are required, then the PRF must be increased even further. This strategy of trading signal redundancy for "processing gain" is similar to how Direct Sequence Spread Spectrum ("DSSS") operates.[20] In a UWB system the UWB equipment will experience significant noise beyond the receiver thermal noise that typically limit the operation of DSSS systems due the very wide band front end and the fact that many other systems will be operating in various parts of the band. Consequently, UWB systems will require either higher power or lower PRFs to achieve the same E_b/N_o as a DSSS operating in a constrained spectrum without the additional noise contributions.

High PRF UWB signals are of a source of particular concern because the interaction of these types of UWB signals with conventional receiving equipment is not

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[20] *See* Terence W. Barrett, *History of UltraWideBand (UWB) Radar & Communications: Pioneers and Innovators*, Progress In Electromagnetics Symposium 2000 (PIERS2000), Cambridge, MA (July, 2000) (providing a good discussion of the tradeoff between data rate and signal to noise for UWB and contrasting UWB with conventional DSSS technology).

well understood. High PRF UWB applications pose a larger threat of aggregate interference because a victim receiver would receive a larger number of pulses from potentially fewer interfering UWB sources. The reaction of conventional receiving equipment to high PRF UWB signals may not be directly tied to the average power of the UWB signals.[21]

There are well know signaling strategies that provide equivalently high data rates (within the existing band allocations) without utilizing such large amounts of bandwidth and thereby exposing many existing systems to the potential for harmful interference. Therefore, until there is a far better understanding of the nature and magnitude of UWB interference, the Commission should be reluctant to authorize moderate to high PRF UWB applications if conventional technologies are available to provide the same services in relatively discrete spectrum segments.

IV. SUBJECT TO THE SUCCESSFUL OUTCOME OF FURTHER INTERFERENCE STUDIES, THE COMMISSION SHOULD AUTHORIZE THE SECONDARY USE OF LOW POWER/LOW PRF UWB TECHNOLOGIES ONLY ON A BLANKET LICENSED BASIS AND NOT PURSUANT TO PART 15 OF THE COMMISSION'S RULES.

While Boeing supports further consideration by the Commission of UWB technologies, Boeing opposes the authorization of UWB systems (regardless of their power and PRF) pursuant to Part 15 of the Commission's rules as unlicensed, low power devices. The potential aggregate impact of ubiquitously deployed UWB systems is too significant for the Commission to authorize using a regulatory structure that provides the

[21] *See supra* at fn. 8 and accompanying text.

Commission with insufficient means to control the number and means of the UWB units in use.[22]

The Commission should instead set appropriate limits for such equipment and authorize them solely pursuant to a new blanket licensing structure. Under such an approach, which the Commission already uses for a variety of other services, a manufacturer would apply for authority to manufacture and market a fixed number of technically identical, low power/low PRF UWB devices. Such authority could be granted pursuant to specific conditions, such as limiting their distribution to public safety agencies, or designing the equipment so that it can operate only when pointed toward the ground. Furthermore, any UWB devices that are authorized by the Commission must be authorized only on a secondary basis to all licensed services especially all aviation and safety of life applications.

The use of a blanket licensing structure would also provide an avenue of recourse for primary spectrum users and the Commission to identify operators of low PRF UWB devices and work with them to correct any unanticipated interference concerns. Without such a blanket licensing structure, the introduction of UWB equipment may lack adequate control and the aggregate interference impacts may be impossible to predict or rectify.

[22] Furthermore, any government use of UWB technology, to the extent that it involves spectrum bands that are allocated for non-government use, or involve shared government/non-government allocations, must be coordinated with the Commission pursuant to Section 4.1.2 of the NTIA Manual of Regulations and Procedures for Federal Radio Frequency Management.

V. CONCLUSION

Boeing supports the consideration and further development of UWB technologies because of the potential public interest benefits that they can provide. Boeing seeks assurance, however, that necessary studies and models will be developed to identify and address all potential UWB spectrum interference concerns, particularly those involving public safety systems such as GPS and aeronautical communication and navigation services. Furthermore, the Commission should consider proposals to introduce relatively low power/low PRF UWB applications (that cannot be introduced feasibly in discrete spectrum segments), on a bifurcated basis from applications using moderate to high power/PRF UWB technology (which can already be provided to consumers in discrete spectrum segments). While the public interest may be served by authorizing the use of low power/low PRF UWB applications on a secondary basis through a process of blanket licensing, it may not be spectrally efficient or in furtherance of the public interest to authorize the introduction of moderate to high power/PRF UWB applications at this time.

Respectfully submitted,

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