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 Systems	)))	Docket No. 98-153

To: The Commission

COMMENTS OF
OAK RIDGE NATIONAL LABORATORY

The Oak Ridge National Laboratory ("ORNL"), pursuant to Section 1.415 of the Commission's Rules, hereby repectfully submits its comments in response to the Notice of Inquiry ("*Notice*") in the above-captioned proceeding. ORNL, located in Oak Ridge, Tennessee, is a large, multidisciplinary research institution within the U.S. Department of Energy (DOE) National Laboratory system and is operated for the Government by Lockheed Martin Energy Research Corporation, a subsidiary of Lockheed Martin Corporation. Although the Lab is primarily devoted to DOE-sponsored research, in areas ranging from particle physics and materials science to environmental studies and genetics, we also perform significant R&D for other Government agencies, including DOD, DOT, EPA, NASA, and the NRC, and for numerous private-sector firms. The staff members in our Instrumentation & Controls Division collectively have many *centuries* of experience in the areas of advanced instrumentation, RF systems, communications (including broadcast, satellite, and special applications), and electromagnetic effects (e.g., EMI, EMP, TEMPEST, shielding, and plasmas). It is our belief that the area of ultra-wideband (UWB) communications is very significant to the Government, industry, and the American people in general. The use of these new technologies potentially offers many useful benefits to the nation, but not without careful technical consideration of their impact on existing equipment and RF communication services, both within Government and the private sector. We are therefore offering several informal comments on the UWB technology itself and some specific suggestions on the Commission's regulation thereof.

(1) In the consideration of the impact of UWB transmitters on existing RF systems, the radiated ***peak*** power ***IS*** what matters, ***NOT*** the power averaged over time. Receivers react instantaneously to a broadband pulse, and they can be significantly desensitized for some amount of time during and after the pulse, due to overloading and "sticking" or clipping in the input stage(s) and subsequent saturation by the large pulse input. A large proportion of existing receivers do not possess exemplary RF selectivity, due to the relatively high cost of complex front-end RF bandpass filters; often the selectivity is obtained by high-Q antenna tuning, which usually exhibits significant out-of-band resonances in addition to the desired fundamental-frequency peaking. In general, the narrower the front-end bandpass filter (BPF), the less UWB energy will be intercepted. However, if the net signal level after filtering is still large, the short UWB pulse, although attenuated, will be substantially lengthened, thus desensitizing the receiver for a significantly longer interval. This same behavior can also occur in the intermediate-frequency (IF) amplifier chain, unless the stages are specifically designed to instantaneously limit, as is the case with most FM receivers. In this scenario, however, the high-amplitude interference causing the limiting will suppress the desired FM signal (generating gross errors for the duration of the pulse-induced limiting) due to the capture effect of the limiter-detector combination. Overall, then, the ***instantaneous interference*** to existing receivers by UWB emitters is the principal concern.

(2) Roughly speaking, each pulse from a UWB system can potentially interfere with non-UWB (conventional) digital receivers within its emission bandwidth whose data-bit periods are less than about ten times the UWB pulse period. For example, if the UWB pulse were 1 ns long, it has the potential to cause bit errors on any transmission system using bit periods shorter than about 10 ns (i.e., data rates greater than 100 Mbits/sec). For higher speed link receivers, where the bit period is close to that of the UWB system, roughly one bit error will occur per UWB pulse. It would therefore appear that to avoid this type of interference to most existing RF data links, a *maximum* pulse width will need to be established for UWB devices unless a suitable frequency-domain specification for the UWB signals can be provided.

Therefore,

(3) ***The standard disclaimer that says that unlicensed equipment must not interfere with other systems should be retained in the language of the Part 15 regulations.*** This would definitely <u>include</u> the required cessation of "harmful interference" as defined in Part 15.

And,

(4) A power-density limit (W/Hz) should be imposed on the overall ***peak*** spectrum of the pulse, probably similar in magnitude to the existing spectral limits used to regulate ***un***intentional transmitters such as computers. Perhaps the existing Part 15 regulations for general-use computers could be extended to higher frequencies. This would give UWB manufacturers a workable ceiling all the way across the frequency spectrum. This spectral limit MUST be applied to the spectral-envelope amplitude of an individual pulse, NOT to the time-averaged amplitude. It is unrealistic to believe that commercial applications of UWB devices will be limited to a few thousand units, as the three UWB system manufacturers have suggested. Once the "cat is out of the bag", we would expect literally millions of UWB devices to be deployed throughout the nation, including many (possibly even a majority) in residences. With even low permitted UWB device emitted power levels, their close proximity to radio and television receivers, remote-control devices, cordless telephones, and the like has the potential to create significant interference to users of these consumer devices, particularly in dense, apartment-style residential structures and other congested urban environments. [It should also be noted that an analysis of multiple UWB devices in a relatively small-area array provided in a submission by one of the UWB proponents, which was intended to address the concern over the cumulative interference effects of large numbers of UWB transmitters, is based on an incorrect assumption. The effective electric-field magnitude from each emitter actually falls off directly with distance (i.e., 1/R), not as the square ($1/R^2$) as stated. This error gives an unrealistically low level of mutual interference from the array; besides, as has been previously noted, the *peak* rather than *average* (RMS) interference power (or field) is the real issue here.]

(5) ***It is strongly recommended that the Commission refrain from relaxing the existing peak, instantaneous power limits for unlicensed Part 15 devices at this time.*** Only after several years of extended experience with the entire gamut of potential UWB devices can their effects on existing and future commercial and consumer receiving hardware (e.g., DTV sets, satellite and GPS receivers, remote controls, cordless phones, as well as regulated devices such as cellular phones, PCS units, pagers, and wireless-LAN transceivers) be fully assessed. Until then, the Commission must take a deliberate, cautious, technically justified approach to this extremely important issue. (It would, however, appear reasonable to make special provisions (e.g., licensing and type-acceptance) for handling specialized UWB applications such as ground-penetrating radar (GPR) which would logically require higher RF power to operate properly, so long as free-air radiated signal-power constraints are retained.) **To limit unlicensed UWB devices to the existing (but proven workable) instantaneous power levels of Part 15, while permitting their general use with reasonable spectral constraints (i.e., low emissions within authorized broadcast, protected, and public-service radio bands), will still allow controlled growth of these new technologies without unnecessarily endangering the vast array of existing RF services that have become an integral element of American society.** In addition, the public will obviously not stand for ***any*** perceived degradation in the performance of such ubiquitous devices as wired telephones, computers, data modems, microprocessor-controlled appliances, advanced "smart" thermostats, RF remote-controlled toys, fans, garage-door openers, intercoms, home medical monitors, and the like. Indeed, even very rare instances of inadvertent operation of such devices by UWB emitters could produce significant safety issues (i.e., an unexpected actuation of a microprocessor-controlled stove or heater by a UWB device) and could lead to major legal liability actions. Since virtually all home power and telephone wiring is completely unshielded against RF interference, and because of the efficient pickup of local UHF/SHF RF sources by the wiring (exacerbated by the relatively short wavelengths employed by typical UWB transmitters), numerous potential opportunities for harmful interference to such devices as those previously cited exist now and will probably grow as the electronic sophistication in the home increases. Few present-day appliances possess sufficient EMI immunity to handle high peak-power UWB interference, and manufacturers of such equipment will undoubtedly be quite reluctant to add cost to their products just to accommodate this increased EMI when there is no clearly perceived customer benefit.

(6) ***A key factor in evaluating the potential of UWB devices to cause interference to more conventional ("narrowband") services is the effective data rate being transmitted by the UWB transmitter.*** Obviously, at very low data rates, the very narrow UWB pulses will be broadcast rather infrequently, their time-averaged power will be low, and the rate of occurrence of individual data errors in narrowband receivers will also be modest. (Of course, more sophisticated conventional systems which employ error-correcting encoding/decoding schemes would not be affected significantly until the interference-induced data-error density [time rate] exceeded the capability of the error-correcting hardware to deal with the resulting error bursts; unfortunately, most existing low-cost RF data links do not incorporate any such error-correcting features.) As the effective UWB-link data rate increases, however, the UWB-induced error rate observed in the conventional receiver's output will increase proportionately. Indeed, at the 100-Mbaud rates touted by some UWB vendors as attainable in future high-speed WLAN applications, many existing narrowband links would be rendered totally unusable! It would appear that the UWB vendors are heavily advertising the non-interfering nature of UWB devices (which would imply low pulse rates – and, thus – low UWB-link data rates) and are yet also claiming that very high data rates can be supported! ***Clearly, the low-interference and high data-rate attributes for UWB devices are mutually exclusive, except at very low power levels.***

(7) In the Notice of Inquiry, the Commission observed that "the wide bandwidth of UWB systems emissions may result in their fundamental emissions being transmitted into the TV broadcast and restricted bands which is prohibited under the Part 15 rules. It is difficult to avoid operating in these bands as the ultra-wide bandwidth is intrinsic to the operation of UWB equipment." Although present first-generation UWB technologies do not exhibit very tight spectral control of their emissions, there also exist several eminently practical techniques for exercising much better control of emitted UWB-device frequency spectra, including filtering, optimized pulse shaping, and tailored antenna designs. Any of these methods, or combinations thereof, can significantly constrain the emitted UWB spectral widths and thereby markedly reduce the RF crosstalk or splatter into the more sensitive bands cited above. UWB systems can thus be fairly easily configured to protect these sensitive areas of the RF spectrum at low cost. ***It is therefore essential that the Commission insist on full protection of these vital existing services from potential interference from UWB devices!***

In summary, we believe that the opportunity for the controlled growth of UWB technology can be accommodated in a manner that will also offer adequate protection for existing services and equipment and thereby serve the "public interest, convenience, and necessity." The adoption of conservative yet workable instantaneous peak emitted power limits for UWB radiators, coupled with existing spectral constraints for unlicensed transmitting devices to protect DTV, GPS, and other key bands, should achieve both ends satisfactorily and assure maximum long-term benefits to the American public.

We sincerely hope that these comments will be of benefit to the Commission in its deliberations on this complex issue, and we would welcome further dialog on this timely subject.

Sincerely,

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