Ultra-Wideband - Promise or Peril?

By Mitchell Lazarus

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Is ultra-wideband (UWB) communications the long-awaited answer to high-speed, low-cost personal-area networking? Or is it too great a threat to aviation and other public safety functions? UWB has triggered the FCC's most hotly-contested technical debate in years. On one side are three start-up companies: XtremeSpectrum, Inc., Time Domain Corporation, and Multispectral Solutions, Inc. On the other side are the entire GPS industry, the PCS industry, the aviation industry, segments of the satellite industry, an alphabet soup of federal agencies, and even amateur radio operators. At the heart of the dispute is one simple question: will UWB cause interference to other users?

Limits on Ultra-Wideband

The advantages of UWB are compelling: an extremely high data rate &#151 100 Mbps, in some implementations &#151 in a small, inexpensive package that consumes very little power. The technology is aimed at extreme short-range applications, about 10 meters maximum. (Other UWB technologies are effective in radar and location applications, but we do not address those here.)

A UWB transmitter uses brief pulses to generate a low-power signal that spreads across several gigahertz. With the signal so thinly distributed, the energy in the passband of a conventional receiver is very low, resulting in a small risk of interference. For that reason the FCC is considering authorizing UWB on an unlicensed basis.

The FCC generally allows unlicensed operation if transmitted emissions are below the so-called &quotClass B&quot levels, which are the same as the noise limits for personal computers. At frequencies suited to UWB communications, Class B is only 75 nanowatts/MHz. But the FCC is concerned that even those numbers might be too high for PCS and GPS. Accordingly, it has proposed to allow UWB at Class B levels at

frequencies above 2 GHz, but to reduce maximum emissions by 12 dB at frequencies below 2 GHz.

The GPS industry objected that even these value are still too high for reliable GPS operation. That drew different responses from the three UWB manufacturers. Time Domain states the original FCC proposal is adequate, while Multispectral Solutions thinks all UWB emissions below 3.1 GHz should be banned. XtremeSpectrum takes a middle position. It says the FCC should allow emissions below 3.1 GHz, for maximum product flexibility, but at the same time should better protect GPS by making the UWB rules more stringent than originally proposed. (The usual disclosure: I represent XtremeSpectrum at the FCC.)

XtremeSpectrum has asked for emission limits a full 18 dB below Class B in the GPS bands. In addition, because some GPS receivers are especially sensitive to line spectra, XtremeSpectrum suggested the FCC require suppression of UWB line spectra in the GPS bands by another 10 dB. Finally, because most GPS use is outdoors, XtremeSpectrum recommends that the FCC limit UWB communications to indoor use only.

Keeping the Noise Floor Stable

Even spectrum users unconcerned about interference from one or two UWB units still might worry about multiple units raising the noise floor. This is understandable, at first glance. We picture an office building holding hundreds or thousands of UWB devices, all operating simultaneously. How could all that RF activity not affect the noise floor?

Surprisingly, that first impression is wrong. UWB transmitters do not add up to raise the noise floor, thanks to propagation losses combined with the very low transmit power of the devices. Even in the open, the useful range of a UWB device is only about 10 meters. But XtremeSpectrum recommends a limitation to indoor use, and that makes the propagation worse. An ordinary interior wall attenuates the signal by at least 10-15 dB, so the signal can barely register in an adjoining room. As a result, the signals from different rooms cannot aggregate.

An analogy may help to clarify the point. Suppose the TVs in every room of a hotel are all playing at once. A person in one room would hear the TV in that room, of course, and might barely hear faint sounds from the immediate neighbors' rooms &#151 but not from any of the others. And a person outside the hotel would hear nothing at all from inside. The &quotaudio noise floor&quot in the vicinity is unchanged.

In just the same way, the very limited propagation of UWB devices prevents their signals from aggregating. Only the nearest UWB transmitter can ever be a potential source of interference. If one UWB device is not a significant interference threat, then neither is a building full of them. It sounds paradoxical, but the mathematics bears it out: UWB is safe for the radio environment, both individually and in large multiples.

Enhanced 911

An indoor UWB unit, operating under XtremeSpectrum's rules, is not likely to disrupt an outdoor GPS receiver, such as one in a passing car. But even an indoor-only restriction does not eliminate all risk of interference to GPS.

The FCC will soon require wireless phone carriers to report the precise location of a wireless phone that dials 911 &#151 a feature called &quotEnhanced 911,&quot or E911. Some carriers plan to comply with the FCC rule by distributing customer handsets that incorporate GPS receivers. In consequence, the UWB rules must

protect a GPS-equipped E911 handset making a call from indoors, possibly in the same room as an operating UWB device.

At the same time, however, an indoor E911 handset has problems much worse than UWB. For one thing, an indoor GPS receiver can't see the satellites directly. For another, it must cope with the RF noise from PCs, printers, copiers, fluorescent lights, elevators, and all the other appurtenances of a modern building. The task would be hopeless for a conventional GPS unit, but the E911 handset has help. A GPS receiver at the cell base station transmits satellite data over the phone channel, and in some systems can also check tentative location readings. These measures let the handset work with a satellite signal-to-noise ratio 20-30 dB lower than otherwise needed. That margin can easily accommodate the UWB signal. In practice, though, the UWB signal is drowned out by other indoor RF interference. (PCs alone can put out GPS-band line spectra 28 dB higher than XtremeSpectrum proposes for UWB.) The presence of a UWB device will not affect the successful operation of E911.

Waiting for the FCC

At this writing (August 2001) the FCC has received almost 700 documents on UWB, totaling thousands of pages. Among these are large technical studies analyzing UWB interference into GPS, PCS, and several federal radar systems. Also included are counter-studies that re-analyze the same data under different sets of assumptions. Because UWB emissions overlap government frequencies, the FCC is coordinating its assessments with the National Telecommunications Information Administration, a Department of Commerce office that in turns coordinates spectrum usage with other government agencies. In the end, the FCC must distill that voluminous input into a workable set of rules.

The FCC's stated goal is a regulatory scheme that lets UWB manufacturers advance the state of broadband wireless technology, while making sure other services are adequately protected. Of particular concern are those services which, like GPS, are not only particularly sensitive to interference, but also demand the utmost reliability.

Even though all parties to the FCC proceeding may never openly agree on a single set of rules, the exchange of studies and comments has greatly narrowed the differences among them. The record establishes that UWB can be regulated so as to eliminate any threat of interference in all but the most implausible scenarios. Under any set of technical rules, one can always invent some set of conditions that results in interference. Much of the remaining disagreement centers on how implausible a scenario can be, and still warrant protection. But the fundamental issues have been worked out, and most parties agree on the broad outlines of UWB regulation. Now the industry is waiting for specific rules that eliminate any realistic peril from UWB, and let its promise be realized.

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