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Ultra-Wideband Technology

by Dale Barr

Introduction

Ultra-wideband (UWB) technology is a revolutionary wireless technology used to transmit large amounts of digital data short distances (up to 230 feet) over a very wide bandwidth (from 1 gigahertz [GHz] up to 10 GHz) and at very low power levels (less than 0.5 milliwatt). Unlike typical radio frequency broadcasts that use continuous sine waves to transmit data, UWB uses precisely positioned pulses at specific time intervals to transmit the signals across a wide spectrum. (See Figure 1.) This effort is accomplished by coordinating a transmitter and receiver to send and receive pulses with an accuracy of within trillionths of a second.

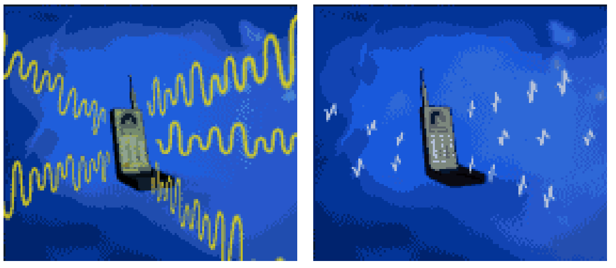

Figure 1. Continuous Sine Waves vs. Time Modulated Pulses

Promoters of UWB technology claim that it provides a low-powered signal that is almost indistinguishable from background noise and uses a wide area of the spectrum without significant interference to other systems. Promoters believe that using UWB technology not only will improve the performance of radar, positioning, and wireless communications, but also will present new possibilities in those areas. Opponents claim that this system could potentially interfere with critical radio signals, such as those emitted from global positioning system (GPS) satellites.

This Technical Note will explore the application of UWB, the potential marketplace, the legal and regulatory landscape, the testing of the technology, and conclusions regarding the future of UWB.

Applications of UWB

With UWB, radio signals can penetrate nearby surfaces while reflecting surfaces that are farther away. This capability would allow radar-type applications to detect objects, such as people or weapons, behind walls or under surfaces (e.g., a collapsed building). UWB technology also can

Application	Commercial Use	Government Use
Asset Tracking—locators/beacons to track mobile inventory and Emergency 911 positioning	✔	✔
Surveillance Radar—radar imaging, precise enough to distinguish specific features on aircraft/marine craft, bringing real-time intelligence to the battlefield		✔
Ranging—commercial/industrial "ranging" applications to determine precise distances between objects	✔	
Security Systems—imaging intrusion systems for alarming and tracking of movement	✔	✔
Through-Wall and Underground Imaging and Radar—detection of objects and conditions through structures	✔	✔
"Smart" Home—wireless links to cable, TV, Internet, computer, and appliances	✔	
Wireless Local Area Networks (LANs)—indoor, short range, high-bandwidth data and video communications where many channels are needed simultaneously (i.e., rural last mile, home server, in-building wireless LANs, and in-building communications)	✔	
Portable Wireless LANs—easy set-up wireless links for data and video transmission to give greater mobility		✔
Covert Communications—radios for squad-level operations that allow anonymous communications without identification		✔

Figure 2. Potential UWB Applications

precisely measure distance and movement to within 1 inch. Precision geolocation systems can locate a person or vehicle by attaching locator beacons that send out signals to receivers so that a precise location can be determined. Beacons could be inserted into pagers, cellular phones, or a vehicle. This technology could aid emergency responders in locating victims, team members, and medical supply trucks, for example. Unlike GPS, this geolocation system could operate indoors, underground, in foliage, in noisy environments, and through bad weather.

With the use of time-modulated digital pulses, UWB allows the use of very low-powered and relatively inexpensive equipment to broadcast signals at very high rates over a large part of the spectrum. This technology may enable the use of public safety devices and wireless communications in areas that suffer from severe multipath and / or high levels of industrial noise and interference. UWB could conceivably be used to provide high-speed Internet access similar to today's wireless modems. Additionally, low-power UWB devices may be non-interfering, which could increase its market value. This technology has led to rapidly growing commercial and government interest in UWB development. Figure 2 lists some UWB applications that could be used in the commercial and government sectors.

The UWB Marketplace

Currently, three companies are influencing the future of the UWB marketplace: Time Domain Corporation; Zircon Corporation; and U.S. Radar, Inc.

Time Domain, headquartered in Huntsville, Alabama, is home to Larry Fullerton, who is credited with patenting time-modulated UWB technology in 1987, although the original technology dates back to the 1940s. Time Domain has developed the PulsON®

chip, a high-speed chip that blends silicon and germanium to provide the time-modulated UWB technology. This chip can be inserted into many different devices to provide UWB technology to the user. Currently, Time Domain is supplying police departments with a system that enables law enforcement officers to covertly communicate with each other. It is also providing a radar system that will enable fire and rescue squads to precisely locate persons trapped inside damaged, burning, or smoke-filled buildings.

Zircon, headquartered in Campbell, California, has been working with UWB since 1980. It is developing a surface probing impulse radar system. Used primarily by the construction industry, this system can detect features, such as electrical wiring conduit, water pipes, and gas lines, behind walls and other surfaces. Zircon will also manufacture and sell electronic hand tools, such as stud locators that can detect wood and metal density differences behind walls, above ceilings, and under floorings.

U.S. Radar, Inc., located in Matawan, New Jersey, is currently marketing SPRscan, a ground-penetrating radar (GPR) system that is used to detect buried objects, such as plastic gas pipes, or reveal structural flaws in roads, bridges, or airport runways.

Two other companies that are studying the uses of UWB are Multispectral Solutions, Inc., and Fantasma Networks.

FCC and NTIA Rules and Regulations

On September 1, 1998, the Federal Communications Commission (FCC), which is responsible for allocating frequencies to non-Federal government users, released a Notice of Inquiry (NOI). The purpose of the NOI was to investigate the possibility of permitting the operation of UWB technology on an unlicensed basis. The NOI requested comments on the standards and operating requirements that would need to be applied to UWB systems to prevent interference with other radio services.

The FCC and National Telecommunications and Information Administration (NTIA) develop rules for operations of unlicensed devices. The NTIA, an agency within the U.S. Department of Commerce (DOC), is responsible for managing spectrum allocated to Federal government users. These rules are detailed in Part 15, Title 47 (47 CFR 15), of the Code of Federal Regulations, which sets forth guidelines and operational policy for all unlicensed devices that transmit a frequency signal, and thus have the ability to interfere with communications within assigned and restricted bands.

Part 15 designates certain sensitive and safety-related frequency bands as restricted. Only spurious emissions not exceeding the general emission limits are permitted within these restricted bands. Such bands include safety spectrum and GPS spectrum, which both possess emergency response and critical communication implications. Ultra-wideband devices emit low levels of power, but because their bandwidths generally exceed 1 GHz and go up to 10 GHz, it is nearly impossible for these devices to avoid placing emissions within the restricted bands.

Based on the comments and replies submitted in response to the NOI, and on preliminary testing from independent sources, the FCC concluded that low-power UWB would be able to operate within the existing spectrum without causing significant interference. The FCC subsequently released a Notice of Proposed Rule Making (NPRM) on May 10, 2000, proposing regulations that would amend Part 15 rules to permit the unlicensed operation of UWB devices. Most

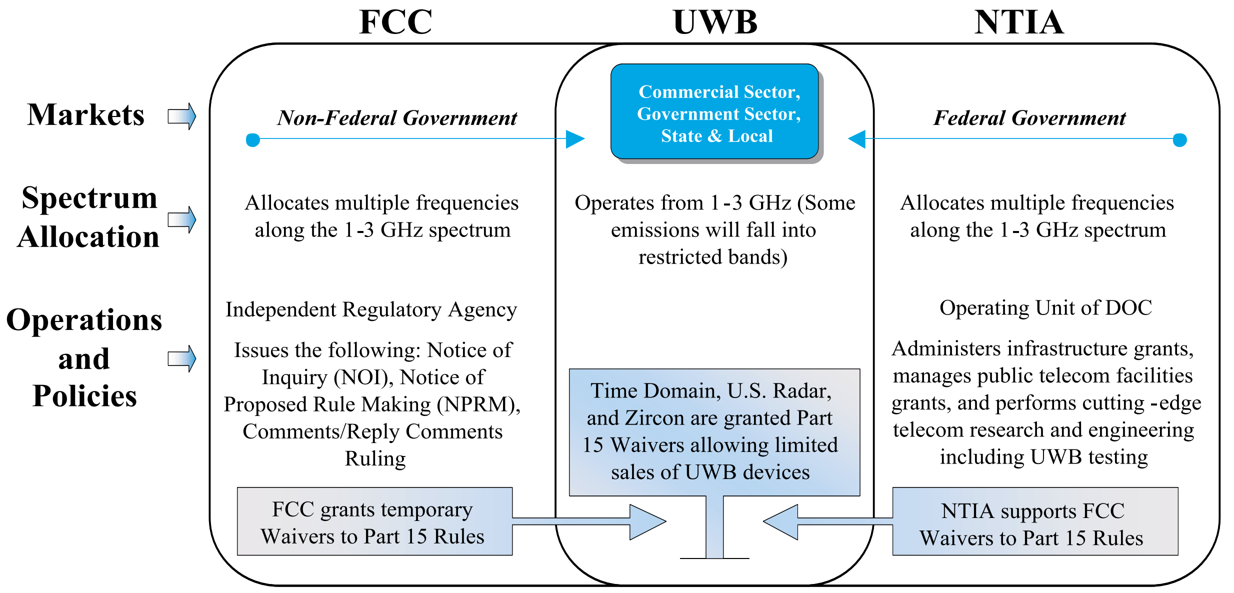

Figure 3. How UWB Correlates With the FCC and NTIA

UWB devices will be marketed for the public; therefore, individual licensing would be unrealistic. The FCC prefers a system with maximum peak emission levels for unlicensed UWB operation, but also recognizes that higher output devices may require special licensing or jurisdiction under another FCC rule. The FCC has requested comments on the text of the NPRM to help develop policy guidelines for amending Part 15.

During the NPRM comment waiting period, temporary waivers have been granted to Time Domain Corporation, Zircon Corporation, and U.S. Radar, Inc. Granted June 29, 1999, these waivers give permission for these companies to manufacture and sell a limited number of UWB devices during a 4-year period. Time Domain's waiver allows it to produce no more than 2,500 units of its UWB system for detecting persons in a building environment. U.S. Radar's waiver permits it to produce 25 units of its GPR system, and Zircon is authorized to build its surface probing impulse radar, limiting sales to professional tradespeople.

Because the waiver requests include UWB intrusion into frequency bands allocated to the U.S. Government, the waivers were coordinated closely in conjunction with the NTIA. In a June 15, 1999, letter, the NTIA agreed with the FCC's decision to grant waivers to the three companies. The NTIA reiterated that all conditions of the waivers should be strictly followed to avoid harmful interference to authorized users. It recommended that all additional waivers be suspended or limited until further tests could be conducted regarding the safety of UWB devices. Figure 3 illustrates how UWB regulation correlates with the FCC and NTIA.

Current Testing

To address concerns over the interference issues, the NTIA's Office of Spectrum Management (OSM) in Washington, D.C., and Institute of Telecommunications Sciences in Boulder, Colorado, have been tasked to obtain test results that will assess the potential for certain classes of UWB systems to interfere with other radio services. The testing will consist of measurement procedures that will accurately measure UWB signal characteristics. The tests will also evaluate the levels of UWB interference to authorized radio communications or sensing systems. The NTIA stated that these test results will be available in early to mid-January 2001.

Because the aviation community has expressed its concerns over UWB's possible interference with the GPS signal used to navigate aircraft and guide missiles, the NTIA will develop a measurement and analysis plan that will address GPS-specific issues. The Department of Transportation is funding tests conducted by Stanford University's GPS Laboratory to study effects of UWB signals on GPS systems within aircraft, specifically during landing and takeoff. Stanford's tests are expected to be completed by the end of January 2001.

On September 7, 2000, the NTIA held the first of several public meetings to define operational scenarios to test for interference between UWB and GPS devices. Attendees that would help define these scenarios included GPS companies and industry organizations, UWB companies, military organizations, and government agencies.

Once scenarios are selected and refined, the NTIA will apply its test data to them and provide the results to the FCC at the end of February 2001.

Tests conducted to date have shown some potential for interference, but further tests are needed to identify the level of interference and whether the UWB signal has a significant effect on other radiocommunication systems.

Conclusions

Since its inception in the 1940s, contributors to UWB development have been searching for practical applications in which to use UWB technology. The timeline in Figure 4 depicts the recent increase in development and testing activity surrounding UWB since the founding of Time Domain and Mr. Fullerton's patented time-modulated UWB technology. With the conclusion of the FCC testing period, commercial deployment of UWB devices could take place as early as 2001.

UWB technology could spur the development of innovative devices that would efficiently

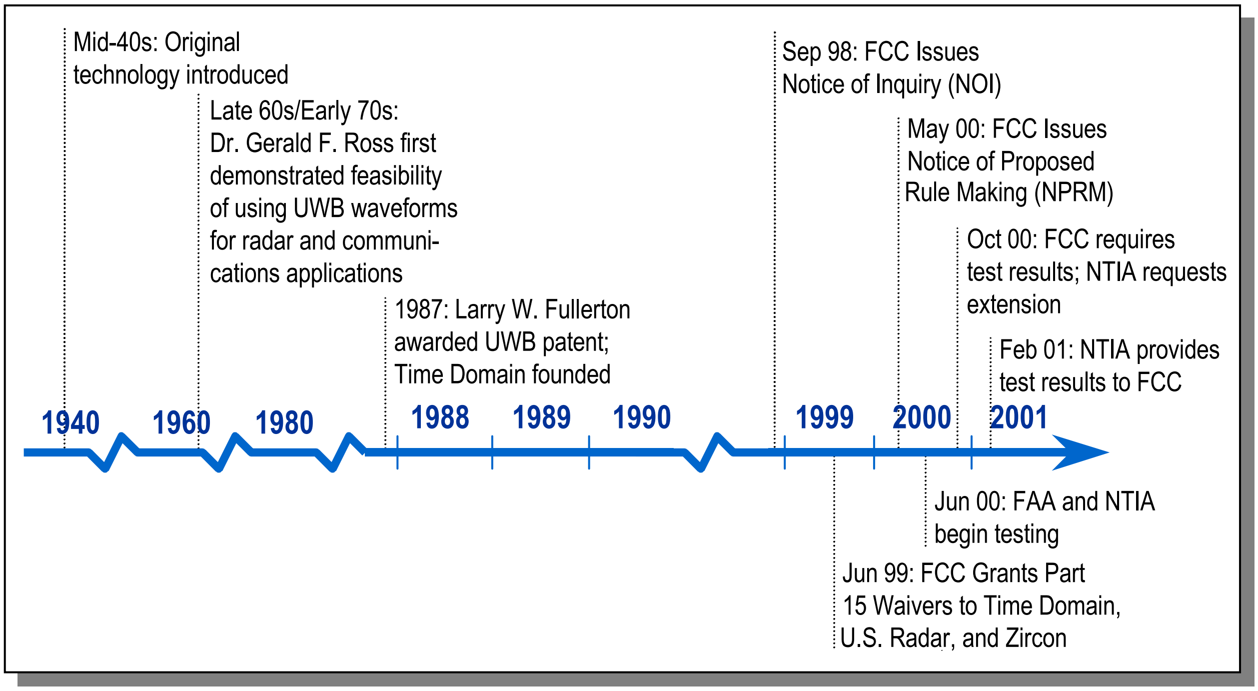

Figure 4. History Timeline of UWB

use the frequency spectrum. With government and nongovernment entities vying for space on the currently congested spectrum, this technology could change the way that frequency has been viewed traditionally.

Future potential technologies could include not only low-power wireless networks linking phones, computers, and televisions without the need for hard-wiring, but also cell phones that could help determine a user's location for a 911 emergency operator. This technology could radically change how national security and emergency preparedness (NS/EP) personnel operate in search and rescue efforts and other crisis events.

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For further information, please contact:

Mr. Dale Barr
National Communications System
Technology and Programs Division (N2)
701 South Court House Road
Arlington, VA 22204-2198
(703) 607-6157