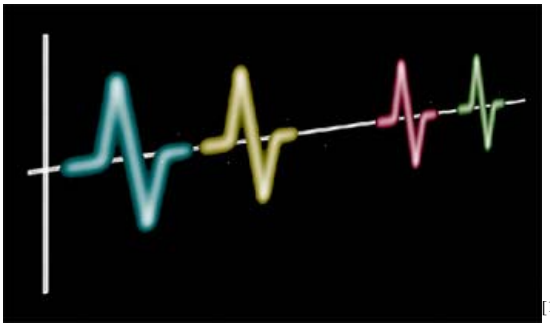
Emerging Wireless Technologies

Ultra Wideband Technology and Its Effects on GPS

Foreword: The Public Safety Wireless Network (PSWN) Program is conducting an ongoing assessment of advancements in the wireless communications industry. The scope of this assessment is to identify emerging wireless services and technologies for potential public safety use in the near future and beyond. This article expands on a previous ultra wideband (UWB) article, concentrating on recent Federal Communication Commission (FCC) rules regarding UWB technology and possible interference with the Global Positioning System (GPS).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Overview

Ultra wideband (UWB) technology can generally be defined as any wireless transmission scheme occupying a bandwidth of more than 1.5 gigahertz (GHz). The Federal Communications Commission (FCC) has proceeded cautiously with the UWB regulatory process because of the uncertainty surrounding UWB interference with other applications such as the Global Positioning System (GPS). Recent studies have determined that first-generation UWB prototype transmitters can interfere with the GPS receiver equipment, a U.S.-built network of navigation satellites that operate in the 1.2 and 1.5 GHz frequency bands.

It is important to minimize, or preferably eliminate, any interference the UWB has with GPS because the public safety community relies heavily on GPS technology. Public safety agencies use GPS for command and control purposes, e.g., determining the nearest location of field personnel to an emergency. Timing is key in emergency response—any interference could be the difference between life and death in such situations.

The FCC recently adopted a *First Report and Order* (ET Docket 98-153) permitting the marketing and operation of certain types of products that incorporate UWB technology. On February 14, 2002, the Order established different technical standards and operating restrictions for three types of UWB devices based on their potential to cause interference. The Order ensures that UWB will not interfere with GPS. This article examines UWB and GPS technologies, interference concerns between the two technologies, FCC rulings, and the impact on the public safety community.

What is UWB Technology?

UWB is a new form of wireless technology based on the transmission of low-powered, coded impulses[1] in a short-range environment. Pulsed transmission is an alternative to using conventional time-varying, sinusoidal waves traditionally used in wireless communications.

This new technology supports direct transmission of digital information as a baseband signal rather than modulating the information within a sinusoidal carrier. Complementary Metal Oxide Semiconductor (CMOS) Integrated Circuit (IC) is used to control the transmission of millions of low-powered, coded pulses at

[1] *UWB devices transmit impulses of power that last for short periods of time—on the order of picoseconds ($1x10^{-12}$)for each transmission, similar to electromagnetic pulses (EMP).*

Application	Commercial Use	Government Use
Asset Tracking—locators/beacons to track mobile inventory and indoor Emergency personnel position finding	✓	✓
Surveillance Radar—radar imaging precise enough to distinguish specific features on aircraft/maritime 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 (Wireless 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—easily set-up wireless links for data and video transmission to give greater mobility (Personal Area Networks [PAN])		✓
Covert Communications—radios for squad-level operations that allow anonymous communications without identification		✓

Table 1 – UWB Applications [2]

precise intervals every second across a large portion of electromagnetic spectrum. Tens to thousands of these pulses are transmitted at different frequencies for every bit of information passed. Upon receipt of the pulses, a communicating receiver processes them using a bank of matched receivers to recover the transmitted pulses. This process ensures precision timing with few errors, which is critical to the device's functionality.

As stated, UWB sends tens to thousands of pulses per bit (ppb) of information at differing frequencies within the 3 GHz to 10 GHz range. As the ppb rate increases, the processing gain[1] increases, and in turn, the bit error rate (BER) decreases. This technique permits a very low-powered signal, with large processing gains. This technique is used in spread spectrum technology to ensure reliable signal transmission over a non-reliable medium, such as the wireless channel

The public safety community can potentially benefit from UWB applications. One such UWB application would allow officials to "see through" concrete and other debris and would be extremely helpful in search and rescue operations. Other UWB applications are listed in Table 1.

What About GPS?

GPS is a satellite navigation system funded and controlled by the U.S. Department of Defense (DoD). It was designed and is widely used for military purposes; however, an increasing number of civilian users also use GPS for navigation, location tracking, and many outdoor recreational activities. GPS provides specially coded satellite signals that can be processed in a GPS receiver, enabling the receiver to compute position, velocity, and time.

1 *Processing gain–UWB receivers can accept multiple pulses per bit; the pulses are averaged for each bit, and that averaging increases the likeliness that each bit will be accounted for—hence a gain.*

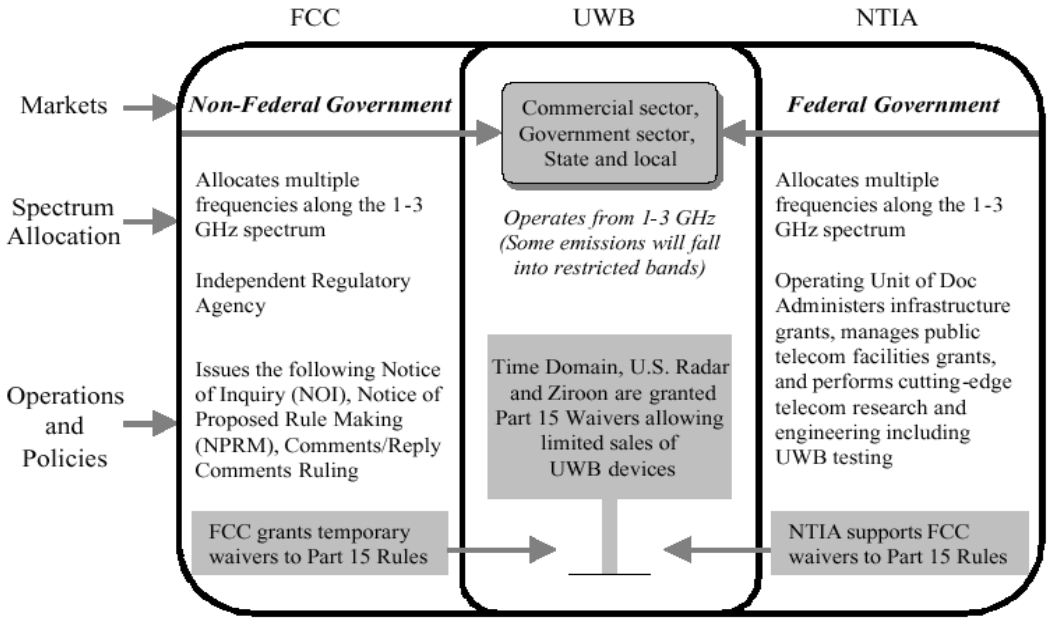

Figure 1 - UWB Regulated by FCC and NTIA [2]

GPS's popularity has grown rapidly since its inception, and the user community wants to limit potential scenarios that might affect GPS performance. Many police, fire, and emergency medical service agencies use GPS receivers for command and control purposes to determine the nearest location of field personnel to an emergency, enabling a faster response time in life-or-death situations. GPS can also provide assistance with search and rescue missions by providing real-time location information while field personnel are searching for victims or suspects. The GPS user community raised the most concern about UWB technology and the potential interference that it could cause to GPS receivers. The potential for this interference has become a major roadblock to the FCC approval of UWB technology.

FCC Ultra Wideband Rulemaking

In September of 1998, the FCC issued a Notice of Inquiry (NOI) to investigate the authorization of UWB transmission systems on an unlicensed basis under Part 15 of FCC Rules. The responses highlighted two main obstacles to UWB operation under Part 15 rules. Part 15 of the rules states that non-licensed operation of low-power transmitter devices is permitted if interference to a licensed radio system is mitigated. However, UWB operation occurs over a wide bandwidth, which can result in transmissions in restricted frequency bands. This is prohibited under the existing Part 15 rules. In addition, the current emission measurement requirements detailed in Part 15 were developed for narrowband systems, and are probably inappropriate for, and possibly pose unnecessary restrictions on, UWB devices.

On May 11, 2000, the FCC issued a Notice of Proposed Rulemaking (NPRM) that proposed that some UWB devices operate on an unlicensed basis under Part 15 Rules. The FCC specifically proposed that safety devices, such as GPS, be protected from harmful interference. Further, this NPRM stated that UWB devices should be exempt from licensing and frequency coordination, allowing the technology to operate under a new UWB section of Part 15 of the FCC Rules. The FCC has proceeded cautiously due to the uncertainty surrounding UWB and whether it will cause

interference with other services, such as cellular telephones and GPS. Figure 1 depicts how the National Telecommunication Industry Association (NTIA) and FCC are involved with UWB regulatory process.

Recent Federal Communication Commission Ruling

The *First Report and Order* issued by the FCC on February 14, 2002, arrived after a long and controversial decision process for the FCC. Because UWB technology employs a range of frequencies already used by wireless telephone carriers and various federal agencies, it took the NTIA 3.5 years to negotiate a compromise that would ensure UWB transmission would not interfere with existing cellular telephone and security systems, as well as GPS. The Order (ET Docket 98-153) permits the marketing and operation of certain types of products that incorporate UWB technology. It also establishes different technical standards and operating restrictions for three types of UWB devices based on their potential to cause interference: imaging systems (including ground penetrating radars [GPR], wall and through-wall imaging, medical imaging, and surveillance devices); vehicular radar systems; and communications and measurements systems.

- **Imaging Systems**—Permits operation of GPRs and other imaging devices under Part 15 Rules, subject to certain frequency and power limitations. At the request of the NTIA, the FCC will notify or coordinate with NTIA prior to the operation of all imaging systems including—

  - **GPRs**—Operate below 960 MHz or in the 3.1 GHz to 10.6 GHz frequency band. Operation is restricted to law enforcement, fire and rescue organizations, scientific research institutions, commercial mining companies, and construction companies.

  - **Wall Imaging Systems**—Also operate below 960 MHz or in the 3.1 GHz to 10.6 GHz frequency band. These systems are designed to detect the location of objects through a "wall." Operation is restricted to law enforcement, fire and rescue organizations, scientific research institutions, commercial mining companies, and construction companies.

  - **Through-Wall Imaging Systems**—Operate below 960 MHz or in the 1.9 MHz to 10.6 GHz frequency band. These systems are similar to wall imaging systems; however, through-wall imaging systems use different techniques to detect the movements of people or objects located behind structures such as walls. Operation is limited to law enforcement and fire and rescue organizations.

  - **Medical Systems**—Operate in the 3.1 GHz to 10.6 GHz frequency band and are used for a variety of health applications at the direction of or under the supervision of a licensed healthcare practitioner.

  - **Surveillance Systems**—Operate in the 1.9 GHz to 10.6 GHz frequency band. Operation is limited to law enforcement, fire and rescue organizations, public utilities, and industrial utilities.

- **Vehicular Radar Systems**—Operate in the 24 GHz band using directional antennas on land transportation vehicles. These devices are used to detect the location and movement of objects near a vehicle, enabling features such as near collision avoidance.

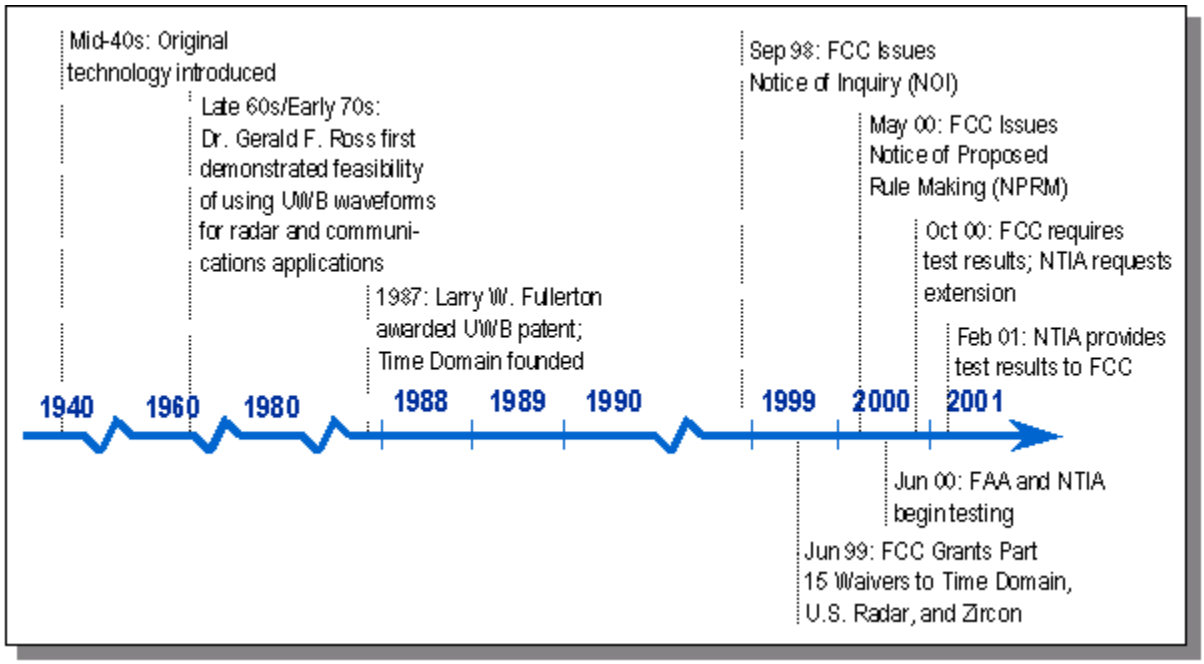

Figure 2 - UWB and Regulatory Timeline [2]

- **Communication and Measurement Systems**—Operate in the 3.1 GHz to 10.6 GHz frequency band. These systems (e.g., wireless LANs) are designed to ensure that operation can only occur indoors.

Figure 2 portrays major milestones in the development of UWB technology and the regulatory process.

Can UWB Interfere with GPS?

Independent research groups have recently performed studies on commercial GPS receivers operating in the same general vicinity as first-generation UWB prototypes. The UWB devices inhibited all GPS functionality within a 20-foot radius of operation. Results from such studies support the FCC's decision to limit full-scale production of UWB equipment until further investigation of UWB interference on other technologies can be performed.

In 1999, the Department of Transportation requested Stanford University to research the compatibility of UWB and GPS and to conduct tests to quantify interference problems. The majority of tests measured UWB impact on the accuracy and performance of a high grade GPS aviation receiver. Other tests measured UWB impact on the loss-of-lock performance for two different receivers, the original aviation receiver and a low-cost original equipment manufacturer's (OEM) receiver similar to devices that will be used in cellular telephones for Enhanced 911[1] location information. In the study released by Stanford University in March 2001, all tests showed the same sensitivity to UWB signal type, and the worst interference cases for all three receivers occurred when a discrete UWB device operated within the GPS band. Further, the Stanford study concluded, "The results strongly suggest that UWB transmissions that overlap or come near to the GPS band must be carefully

[1] *A detailed description of Enhanced 911 (E911) can be found on a previous Emerging Technologies article titled, "Enhanced 911– Enhanced Wireless Emergency Communications."*

regulated to ensure that there is no adverse impact to GPS."

As a result of the NPRM issued by the FCC on May 11, 2000, the NTIA conducted two studies to determine whether UWB interferes with GPS. In March 2001, the NTIA issued a report concluding that some UWB signals examined during testing "exceeded measured GPS performance levels" at output levels "well below" other unlicensed devices, such as cordless telephones. The report also cautioned that UWB devices need to operate at very low emission levels to avoid interference with GPS signals.

Johns Hopkins University issued a study that concluded UWB could operate in ways that make its transmissions appear similar to the regular background noise of miscellaneous radio transmissions. Johns Hopkins researchers concluded that varying the timing of the UWB pulses, via a process called "dithering," could make the signal more "noise-like." However, the study cautioned that some pulse frequencies could interfere with GPS receivers.

As the studies mentioned above conclude, UWB transmissions can interfere with GPS technology. With this knowledge, it is clear why the FCC has decided to proceed with caution regarding proposing new rules relating to the proliferation of UWB technology. Because several future products may lend themselves to better mitigating interference-related problems with the GPS system, the FCC will reevaluate its decision in the *First Report and Order* in 6 to 12 months.

Impacts on the Public Safety Community

During the rule making process for UWB, the Association of Public Safety Communications Officials (APCO) International requested that the FCC "proceed with great caution." APCO is concerned about potential interference from UWB transmissions with radio systems used by police, firefighters, and emergency medical workers, and to GPS-based technologies used to locate emergency callers. The Commission is actively listening to concerns voiced by the NTIA, the Federal Law Enforcement Users Group (FLEWUG), and the public safety community in general. The *First Report and Order* ensures protection from interference while allowing use of new mission-critical equipment for urban search and rescue and other related functions.

Conclusion and Future Challenges

In this article, the following topics were discussed: UWB and GPS technologies, interference between the two technologies, and recent FCC rulings. UWB applications may greatly benefit the public safety community; however, challenges still exist in ensuring the technology benefits its users and does not adversely affect other important technologies, such as GPS. The regulatory process is still progressing, but it is anticipated that standardization efforts that mitigate effects of UWB transmission on other technologies will be required before UWB becomes widely available to the consumer market.

This article also identified the importance of GPS to public safety organizations and other areas such as the aviation industry. In summary, UWB does interfere with GPS in certain situations. Although one main beneficiary of the applications available through UWB technology will be the public safety community; the technology will not be useful if it interferes with other critical technologies, such as GPS-based applications. The FCC is taking the necessary steps to ensure this does not occur.

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