Pakistan Telecommunication Authority

A Report on Ultra Wide Band (UWB) Application

Year 2012

This report deals mainly with the understanding of UWB technology, some types of applications where UWB technologies are being used and development of regulatory arrangements to support ubiquitous, low-power, short range UWB technologies.

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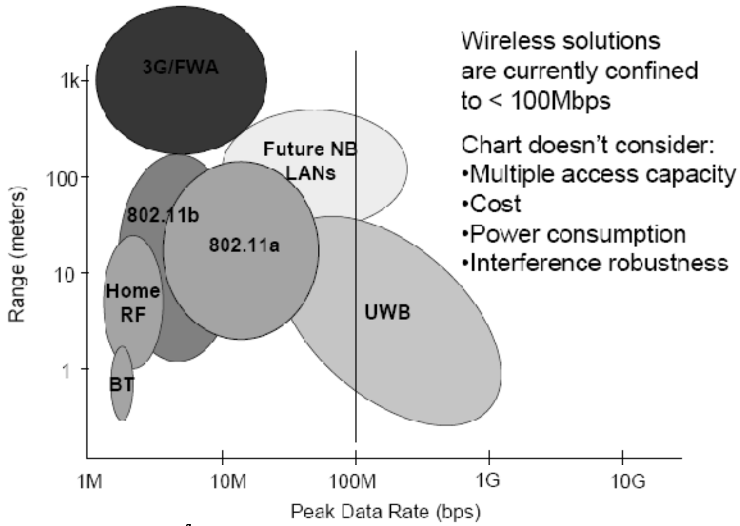
1. Introduction

UWB is a technology developed to wirelessly transfer large amounts of data over short distances, typically around ten metres. Unlike other wireless systems, which utilise spectrum in discrete narrow frequency bands, UWB operates by transmitting signals over a very wide spectrum of frequencies. It is an alternative to other wireless technologies, such as Bluetooth and WiFi, for Personal Area Network (PAN) applications.



Source: Intel Labs[1]

The principal advantages of UWB over alternative technologies are much faster data transfer rates (100 Mbps or greater) and extended device battery life. It may also offer some cost advantages, if chipset production volumes are sufficiently high. Regulations for use of UWB are already in place in many countries of the world and vendors are producing compliant chipsets. Two contender UWB approaches have mostly being adopted, for which the standards have been developed by IEEE standardisation group:

- a Direct Sequence CDMA standard (DS-UWB); and
- a variant using a multi-band approach with Orthogonal Frequency Division Multiplexing (MB-OFDM).

Some of the UWB technology applications operating in different parts of the radiofrequency spectrum include:

- Ground Penetrating Radar,
- Security Monitoring and Imaging Systems,
- Medical Imaging Applications,
- Precision RFID
- Personal Area Networking
- Short range high speed data links for connecting consumer equipment such as cameras and computers.

[1] http://www.3g4g.co.uk/Other/Uwb/Wp/uwb.pdf

With the characteristics of low power, low cost, and very high data rates at limited range, UWB is positioned to address the market for a high-speed wireless personal area networks (WPAN).

The Short Range Devices (SRD) using UWB technology can be used for communications, measurement, location, imaging, surveillance and medical systems.

1.1 Overview of Ultra-Wideband (UWB) technology

Ultra Wide-band (UWB) technology involves the radiation, reception and processing of very wide bandwidth radiofrequency emissions. Consequently, these emissions typically occupy a portion of the radiofrequency spectrum, sweeping a number of frequency bands allocated for different purposes. So, unlike other wireless systems, which utilise spectrum in discrete narrow frequency bands, UWB operates by transmitting signals over a very wide spread of spectrum.

The Federal Communications Commission (FCC) of the United States of America defined UWB technology as:

‘ A technology utilising an instantaneous emission bandwidth greater than 500 MHz; or alternatively, bandwidths greater than 20% of the centre frequency for centre frequencies below 2.5 GHz.’

These very large bandwidth emissions were originally created using ultra-short (nanosecond scale) pulse waveforms. However, more traditional broadband modulation techniques such as code-division multiple access (CDMA) and orthogonal frequency division multiplexing (OFDM) have been used to generate ultra-broad bandwidth emissions in recent times.

Fractional Bandwidth is the ratio of signal bandwidth (10 dB) to center frequency: $B_f = B / F_C = 2(F_h - F_l) / (F_h + F_l)$ [2]

UWB technology has greater capacity than other radio technologies in transmitting data in cluttered indoor environments because of the extreme broadband nature of emission. This broad bandwidth reduces the impact on the received signal level caused by frequency selective multipath and RF absorption events in a cluttered environment. UWB technology also provides an advantage when used to collect data for the precision analysis of internal structures and movement of object by radar or radio determination systems.

UWB radios mostly use frequencies from 3.1 GHz to 10.6 GHz – a band more than 7 GHz wide. Each radio channel can have a bandwidth of more than 500 MHz, depending on its centre frequency. To allow for such a large signal bandwidth, the FCC put in place severe broadcast power restrictions. By doing so, UWB devices can make use of an extremely wide frequency band while not emitting enough energy to be noticed by narrower band devices nearby, such as 802.11a/b/g radios. This sharing of spectrum allows devices to obtain very high data throughput, but they must be within close proximity.

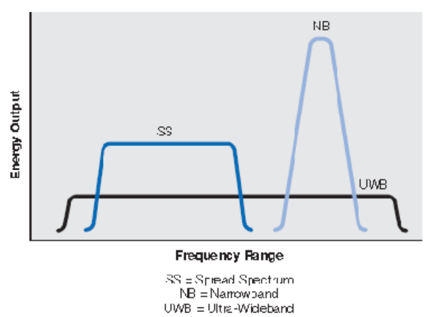
[2] http://www.acma.gov.au/webwr/_assets/main/lib311844/ifc1010_ultra%20wide%20band_consultation%20paper.pdf

Following is the figure identifying various technologies in respective frequency bands and their approximate emitted power.

1.2 Comparison of UWB with Narrow Band and Spread Spectrum

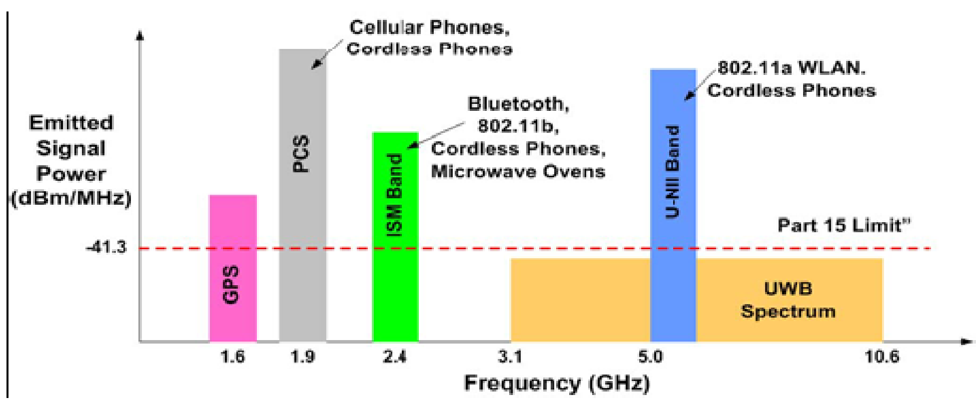
UWB differs substantially from conventional narrowband radio frequency (RF) and spread spectrum technologies (SS), such as Bluetooth Technology and 802.11a/b/g. UWB uses an extremely wide band of RF spectrum to transmit data. In so doing, UWB is able to transmit more data in a given period of time than the more traditional technologies.

Comparison of narrowband (NB), spread spectrum (SS), and ultra-wideband (UWB) signal concepts



Source: Intel

Bluetooth Technology, 802.11a/b/g Wi-Fi, cordless phones, and numerous other devices are relegated to the unlicensed frequency bands that are provided at 900 MHz, 2.4 GHz, and 5.1 GHz.



Source: 2006 IEEE Ninth International Symposium on Spread Spectrum Techniques and Applications[3]

Each radio channel is constrained to occupy only a narrow band of frequencies, relative to what is allowed for UWB. UWB technology also allows spectrum reuse. A cluster of devices

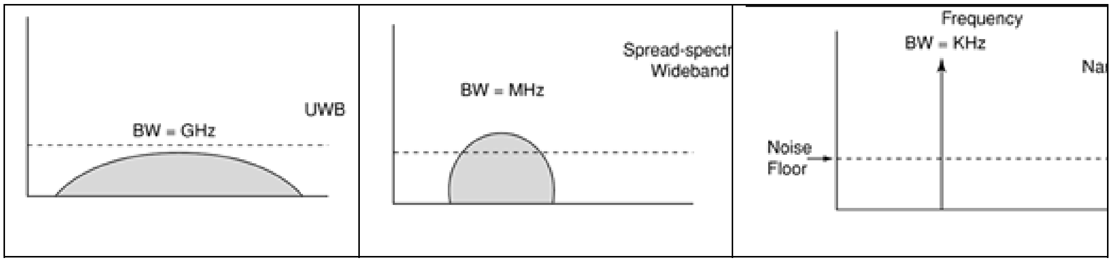
3 http://www.google.com.pk/url?sa=t&rct=j&q=Short+Range+devices+and+UWB&source=web&cd=13&ved=0CEsQFjACOAo&url=http%3A%2F%2Fciteseerx.ist.psu.edu%2Fviewdoc%2Fdownload%3Fdoi%3D10.1.1.85.5322%26rep%3Drep1%26type%3Dpdf&ei=i2m_T7e7HMPorQeBmcy3CQ&usg=AFQjCNGpWS5csREVGfwZ_q9oZE_BREF73g

in proximity (for example, an entertainment system in a living area) can communicate on the same channel as another cluster of devices in another room (for example, a gaming system in a bedroom). UWB-based WPANs have such a short range that nearby clusters can use the same channel without causing interference. An 802.11g WLAN solution, however, would quickly use up the available data bandwidth in a single device cluster, and that radio channel would be unavailable for reuse anywhere else in the home. Because of UWB technology's limited range, 802.11 WLAN solutions are an excellent complement to a WPAN, serving as a backbone for data transmission between home clusters.[4]

Wireless technologies such as 802.11b and short-range Bluetooth radios eventually could be replaced by UWB products that would have a throughput capacity 1,000 times greater than 802.11b (11M bit/sec). Those numbers mean UWB systems have the potential to support many more users, at much higher speeds and lower costs, than current wireless LAN systems. Current UWB devices can transmit data up to 100 Mbps, compared to the 1 Mbps of Bluetooth and the 11 Mbps of 802.11b. Best of all, it costs a fraction of current technologies like Blue-tooth, WLANs and Wi-Fi.[5]

UWB[6]	**Spread Spectrum**[7]	**Narrow Band**
In UWB communications, there is no carrier frequency; the short duration of UWB pulses directly generates an extremely wide bandwidth.	The signals are continuous-wave sinusoids that are modulated with a fixed carrier frequency. Information can be sent using narrowband carrier signal spread out over a much larger frequency range.	Uses only enough frequency to carry data (& NO MORE)
UWB pulses provide several gigahertz of bandwidth	SS can offer megahertz of bandwidth	
Peak signal power is a below the inherent noise floor	Peak signal power is a little above the inherent noise floor	High peak power (more power required to use a smaller frequency range). Signal must stand out above inherent RF noise level (noise floor) in order to be received
	Probability of signal corruption or jamming is greatly reduced receivers	Can be jammed easily
Data rates around 100Mbps	Peak data rate Bluetooth(802.15) 1 Mbps WLANS(802.11x) 11 Mbps	
DC-CDMA MB-OFDMA	Frequency Hoping (e.g. FHSS), Direct Sequence (e.g. DSSS)	

4 http://www.3g4g.co.uk/Other/Uwb/Wp/uwb.pdf
5 http://www.projects-forum.com/Thread-Ultra-Wideband
6 http://www.informit.com/articles/article.aspx?p=433381&seqNum=7
7 www.unix-edu.se/share/wlan/Chapter_3.pdf



Source:

2. Ultra-Wideband (UWB) Applications

There are a large range of likely UWB technology applications operating in different parts of the radio spectrum. In general, FCC has categorized the UWB devices broadly into three different types of UWB applications, according to its potential to cause interference to the existing radio communications services, i.e. Communications systems, Imaging and Vehicular radar while the ECC, at this stage, only considers the first two types, excluding Vehicular radar. Accordingly, specific emission limits and operation guidelines are designed to mitigate interference for each type of UWB application.

2.1. UWB Communications and Measurement systems(Type 1)

This tpye of applications have different usage patterns. e.g. The can be used for outdoor/indoor/hot-spot deployment and the have different device density and utilisation rate. The frequency bands used by most of Type-1 applications are from 3.1GHz to 10.6 GHz.
The use of UWB technology in low intercept and detection probability communications systems evolved in the 1980's in response to the needs of Government agencies. However, UWB technology is being used more recently in next generation radio Local area network (RLAN) devices replacing the spread spectrum and orthogonal frequency division multiplex (OFDM)[8] technologies that are currently in use.

Wireless technologies such as monitors, wireless printers, attach different type of devices with the help of wireless media to the computer system.

With the help of application of the ultra wide band technology users can develop the photographs without attaching with the computer also. Some examples of type 1 are

- Consumer and business data communication applications, for example:
  - Home entertainment and networking/ Digital Home (indoor, high density, in average low utilisation);
  - Cellular phones' multimedia interfaces (outdoor and indoor, high density, medium utilisation);
  - Wireless Personal Area Networks (WPAN) (indoor, hot-spot, low-to-medium utilisation);
  - Wireless Local Area Networks (e.g. similar to RLAN with enhanced capacity, indoor, hot-spot, high utilisation);

[8] http://www.wifinotes.com/UWB-Technology.html

- Combined data communication and measurement systems, e.g. measurement and location recording devices (outdoor and indoor, low density, low utilisation).

2.1.1. Digital Home

The emerging digital home environment is made up of many different devices (e.g., digital video and audio players), mobile devices (e.g., cellular phones and PDAs), and personal computing devices (e.g., mobile notebook PCs) that will support a multitude of applications. These devices fall into three general overlapping categories :

- PC and the Internet
- Consumer electronics and the broadcast system
- Mobile and handheld devices

These devices have traditionally been kept in different rooms and used for different functions. Increasingly, however, owners expect them to interact – MP3 players exchanging files with PCs, digital video recorders communicating with STBs, etc. This convergence of device segments calls for a common wireless technology and radio that allows them to easily interoperate and delivers high throughput to accommodate multiple, high speed applications. Currently, these segments utilize different interfaces and content formats[9].

The next generation of PC, consumer electronics, and mobile applications demand connectivity speeds beyond the 1 Mbps peak data rate of Bluetooth Technology, which is used by many devices to create WPANs today. But many CE devices cannot support the cost and power required by the higher speed 802.11a/b/g radios for Wi-Fi networking.

While Wi-Fi is much faster than Bluetooth Technology, it still does not deliver sufficient performance to effectively allow streaming of multiple simultaneous high-quality video streams. UWB technology provides the throughput required by the next generation of converged devices. Plus, the support of industry initiatives, such as the WiMedia Alliance, will help ensure interoperability across multiple protocols, including IEEE 1394, USB, and Universal Plug and Play (UPnP), making UWB a broad technology solution for creating high-speed, low-cost, and low-power WPANs.

2.2. UWB Imaging systems(Type 2)

They are used both for indoor and outdoor, low density, low-to-high utilisation, are used mostly in possible safety applications. The frequency band these Type 2 applications mostly use are 0-960 MHz . Type 2 applications include:

- Ground Penetrating Radars (GPRs);
- People Imaging and Baggage scaning;
- Through-wall imaging;
- Medical imaging;
- Surveillance devices;
- Industrial liquid level gauges.

[9] http://www.intel.com/technology/comms/uwb/download/ultra-wideband.pdf

2.2.1. Through Wall Imaging

UWB technologies have been used in "see through the wall" precision radar imaging systems. These types of imaging systems were one of the first applications to make use of UWB emissions and were used by the United States military. The need for systems that could be used to identify camouflaged and buried installations was a key driver in the development of UWB technology. The technology has evolved from techniques and equipment developed to measure the impulse response of microwave networks and wideband antenna elements. Frequencies in the lower part of the radiofrequency spectrum, below 1 GHz for example, are able to penetrate the surface of the ground and other solid features and are useful in the detection of buried objects, such as bodies, and providing through-wall security monitoring. These systems have uses extending beyond the military public security and protection organisations. These applications could also have medical or industrial use including diagnostic imaging and the identification of underground services.

2.2.2. Medical Imaging:

In the medical application, the relative dielectric properties of living tissues are very varied offering large contrasts to the UWB imaging modality. In particular some types of cancer have been shown to have dielectric constants and RF conductance that are more than a factor of 5 greater than normal healthy tissues.[10]

2.2.3. People imaging and baggage scanning

UWB has been used for People imaging and baggage scanning for the detection of concealed weapons and explosives.

2.2.4. Material Sensing Devises

2.2.4.1. Building material Analysis

BMA devices can be described as field perturbation (intrusion) sensors, or radio determination systems, that are designed to detect the location of objects within a building structure or to determine the physical properties of a building material.

2.2.4.2. Object Discrimination and Characterization Devices (ODC)

In case of ODC devices, two types of applications were distinguished in the compatibility studies:

- Proximity Sensing of Human tissue
- "Break through" protection and direct contact avoidance for building work

Proximity Sensing of Human tissue is intended for:

- Detection of small objects like a finger or other extremities in the presence of obstacles (e.g. wood), positioned close to a hazard like a saw blade;

[10] http://www.roke.co.uk/resources/papers/UWB-3D-Imaging.pdf

- Applications typically for consumer market, like safety devices for power tools or dangerous machines; usage in close proximity to potentially hazard area (0 to 40 cm)

“Break through” protection and direct contact avoidance for building work is used for high end drilling and percussion drilling machines. It is planned to mount it directly to the tool. A parallel usage is possible. The UWB sensor application monitors the drilling process and controls the drilling machine also depending on the in-homogenities in the material. The user will be warned acoustically or optically in case of a collision with unexpected objects inside the material (e.g. gas- water pipes or electric cables) may happen. The UWB application may be active synchronously to the operation of the drilling machine which will be supported by this application.

The detailed compatibility studies performed by CEPT[11] considered the specific deployment scenarios and mitigation factors of BMA or ODC and have led to highly specific requirements in different frequency bands, taking into account specificities of the victim services and operational requirements for BMA or ODC.

2.3. Automotive radars (Type 3)

These type of applications dosnt use frequencies less than 10.6 GHz. FCC[12] uses 76 – 77 GHz band for this purpose, Ministry of Post and Telecommunication (MPT) of Japan allocated 60 - 61 GHz band and the 76 – 77 GHz band for this purpose, European Telecommunications Standards document EN 301 091 1998-06 which applies to automotive radar equipment in the 76 - 77 GHz bands.

2.3.1. Vehicular radar systems

The Short-range Automobile Radar frequency Allocation (SARA) and its devices are being promoted internationally by the automotive and electrical manufacturing industries as a high volume use of UWB technologies. The proposed short range (<30m) radar systems aim to achieve high range and position accuracy to provide locali collision avoidance, restraint system arming and parking assistance in the next generation of motor vehicles.

According an CEPT report,[13] “Considering proportions of UWB Types 1 and 2 in a total number of forecasted UWB units, based on information provided by UWB industry, 98% of deployed devices should be covered by type 1. Furthermore, 88% of all units would be type 1 for indoor use exclusively and only 10% for outdoor applications”. Cellular communication industry’s plans to integrate UWB data interface into mobile terminals might change the aforementioned proportion of type 1 devices between indoor and outdoor applications.

3. UWB Regulatory Development

There is a lot of work and research on UWB being done by international regulatory authorities to consider the implementation of planning and standards arrangements.

3.1 The Federal Communications Commission (FCC)

[11] http://www.erodocdb.dk/doks/relation.aspx?docid=2338 ECC analysis on these applications
[12] http://www.acma.gov.au/webwr/radcomm/frequency_planning/spps/0104spp.pdf
[13] http://www.erodocdb.dk/doks/relation.aspx?docid=2338 (Generic UWB Application below 10.6 GHz)

FCC believes that the combination of technical standards and operational restrictions will help to ensure that UWB devices can coexist and give adequate protection to other radio communication services. In view of the unclear impacts cause by UWB devices, the FCC adopted a cautious approach in devising its standards.

In the First Report and Order[14], FCC concluded that low-power UWB devices indeed can operate within the existing spectrum without causing significant interference (with few exceptions, like FCC did not consider a 1 dB noise rise significant in this regard, and they assumed cellular services to have a higher level of received signal than is often the case in practice). Hence, FCC amended its rules to permit UWB operation without a license. It also permited the marketing and unlicensed operation of range of products based on UWB technology including indoor and handheld devices with following specifications:-

- Must contain frequencies between 3.1 GHz and 10.6 GHz.
- The maximum mean radiated power spectral density in this band is limited to -41.3 dBm/MHz.

For regulatory purposes, FCC established various technical standards and operating restrictions for 3 types of UWB devices:

1) Communications systems;
2) Imaging systems (including ground penetrating radars); and
3) Vehicular radar systems.

The classification for each type of UWB devices is based on their potential to causing interference to the existing licensed users in the 3.1-10.6 GHz frequency band. Accordingly, emission limits are designed for each type of UWB devices to further mitigate interference.

In December 2004, FCC released its Second Report on UWB[15]. In this report, they provide greater flexibility for the introduction of wide-bandwidth devices and systems which do not fall into the classification of UWB technology. Under the new rules, the peak power limits for wide-bandwidth device emission is raised to the same level as UWB devices in the three frequency bands already made available for unlicensed operation, i.e. 5925-7250 MHz, 16.2-17.2 GHz and 23.12-29 GHz. In addition, the Commission amended its measurement procedures to permit frequency hopping, swept frequency, and gated systems operating in these bands to be measured in their normal operating mode

3.2 Electronic Communication Committee (ECC)

Unlike the FCC which has 3 types of UWB devices, ECC only considers, at this stage, 2 main types of UWB systems that operate below 10.6 GHz:

[14] FCC 02-48, “Revision of Part 15 of the Commission’s Rule Regarding Ultra-Wideband Transmission Systems”, First Report and Order, ET 98-153; adopted: February 14, 2002; released: April 22, 2002

[15] FCC 04-285, “Revision of Part 15 of the Commission’s Rule Regarding Ultra-Wideband Transmission Systems”, Second Report and Order and Second Memorandum Opinion and Order, ET 98-153; adopted: December 15, 2004; released: December 16, 2004.

1) UWB communications systems; and

2) UWB imaging systems.

In February 2005, the Electronic Communications Committee (ECC) published a ECC Report[16] that described the general limits for UWB applications, in terms of maximum power spectral density (PSD), required to protect radio communication services below 10.6 GHz. While the report is largely based on theoretical analysis, the ECC report determines maximum generic UWB PSD values more stringent than those values illustrated in the FCC's e.i.r.p density limits by 20-30 dB, reflecting the higher density of other devices in use or anticipated 2-5 GHz. The ECC highlighted that the assumptions used in the report are highly dependant on deployment parameters such as UWB device densities and activity factors, aggregate interference cases and protection distance requirement for single interference cases.

In March 2006, the ECC released its Decision[17] (amended in July 2007), in relation to the harmonised introduction of generic devices using UWB in bands 6-8.5 GHz. The Decision included the exemption of individual licensing and that UWB devices are allowed to operate on a non-interference and non-protection basis. However, the Decision does not apply to flying models, outdoor installations and infrastructure, including those with externally-mounted antennas and devices installed in road and rail vehicles, aircraft and other aviation. In addition, any UWB devices that are within the scope of the Decision are also not allowed to be used at fixed outdoor location or connected to a fixed outdoor antenna. The ECC further approved 2 new Decisions relating to the harmonised introduction of UWB devices in the European Union. Under the new approved Decisions, UWB devices implemented with Low Duty Cycle (LDC) are permitted to operate in the frequency band 3.4 to 4.8 GHz at -41.3 dBm/MHz; same level adopted by FCC. And in view of unproven mitigation techniques such as Detect and Avoid (DAA), the ECC will further investigate the effectiveness of DAA in protecting radars below 3.4 GHz. The other Decision approved by ECC is to address the issue of imaging applications (Ground-and Wall-Probing Radar) which did not fit within the generic UWB PSD limits made in the first ECC Decision in March 2006. As a result, ECC decided to use new emission limits for GPR/WPR applications and radio interface parameters for EU members to adopt.

The ECC Report 94 concluded that sharing the frequency band with UWB devices implemented with LDC will result in minor impact on WiMAX services, unless adequate proximity distance is maintained between the two applications.

In Feb 2007, the Europe Commission (EC) announced its Decision [8] to allow the use of spectrum by equipment using ultra-wide band technology and to harmonise the conditions throughout Europe. As for equipment operating in the 4.2-4.8 GHz band without mitigation technique, the EC decided that such equipment replace by more restrictive conditions beyond the date of 31 December 2010.[18]

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[16] ECC Report 64, "The Protection Requirements of Radio-Communications Systems Below 10.6 GHz from Generic UWB Applications" by Helsinki, February 2005.

[17] ECC/DEC/(06)04, "ECC Decision of 24 March 2006 amended 6 July 2007 at Constanta on the harmonised conditions for devices using Ultra-Wideband (UWB) technology in bands below 10.6 GHz", released: March 2006 and amended 6 July 207.

[18] http://www.apt.int/AWF-RECREP

3.3 International Telecommunication Union (ITU)

As per ITU, UWB devices should not cause harmful interference to a radiocommunication service and shall not claim protection from interference to which they may be subjected. In other words, UWB devices are expected to operate on a non-interference and non-protection basis.

ITU has completed its work on the UWB framework which should be used as a guide by administrations when considering the introduction of devices using UWB technology. While the recommended framework aims to protect the existing radio communication services from interference, it is not intended to hinder the development of devices using UWB technology. However, the administrations will have to make their own analysis on mitigation factors and parameter sets that is most suitable for their respective situations.

In developing a national framework for UWB, ITU put forward 2 possible implementations:

1) a generalised regulatory; and

2) an application-dependent regulatory.

For the generalised regulatory implementation, the administrations may consider imposing usage restrictions, technical limits and controls (i.e. activity factors and UWB power spectral density), and mitigation techniques to address interference concerns. For application-dependent regulatory implementation, the approach is to restrict the use of certain UWB devices (i.e. imaging devices and automotive short-range radar) in certain premises and allow specific group of people to operate these devices.

The recommendation includes the impact of devices using UWB on radio communication services. The emphasis is to evaluate the permissible UWB EIRP density in order to ensure proper protection of existing radio communication services operating within the frequency band.

ITU-R TG 1/8 proposes three general categories of victim receivers, as listed in Table 1.

Category	Designation	Victim Service/Application	Dominant Interference Scenarios
A	Mobile and portable stations	- Mobile handset (GSM, DCS1800, IMT-2000, MSS, RNSS), - Portable broadcasting receiver (ATSC-DTV, T-DAB, DVB-T, Analogue TV, Digital FM, ISDB-T, ISDB-T_{SB}), - RLAN, Indoor FWA	Single-entry interference
B	Fixed outdoor stations	- FS station (P-P, P-M-P) - Base station from the mobile service - Radio astronomy station - Earth station (FSS, MSS) - Broadcasting fixed outdoor receiver - Radar station	Aggregate interference from surrounding UWB Single-entry interference
C	Satellite/aeronautical on-board receivers	- Satellite receiver (EESS, MSS, FSS)	Aggregate interference from

		- Aircraft stations	large scale area

Table 1: Categories of Victim Receivers (Source: ITU-R TG 1/8)

Table 1 shows the impact on the different categories of victim receivers from single device and the aggregate effects from multiple UWB devices in different pre-defined deployment scenarios. The objective of the study is to provide a guideline for administrations on the maximum EIRP density and separation distance that should be observed for each category of victim receivers.

Summary of Regulatory models for various countries –Indoor UWB Devices

	Country/Organization	Frequency Bands	In-Band Limitations
1.	USA (FCC)	3.1-10.6 GHz	-41.3 dBm/MHz and 0dBm/ 50 MHz peak
2.	Canada	4.75 to 10.6 GHz	-41.3 dBm/MHz and 0dBm/ 50 MHz peak
3.	Europe (CEPT)	3.4 to 4.8 GHz	Low duty cycle -41.3 dBm/MHz and 0dBm/ 50 MHz peak
		4.2 to 4.8 GHz	-43.3 dBm/MHz and 0dBm/ 50 MHz peak Until December 2012 without mitigation
		6.0 to 8.5 GHz	-41.3 dBm/MHz and 0dBm/ 50 MHz peak
4.	UK (Ofcom)	3.4 to 4.8 GHz	Low duty cycle -41.3 dBm/MHz and 0dBm/ 50 MHz peak
		4.2 to 4.8 GHz	-41.3 dBm/MHz and 0dBm/ 50 MHz peak
		6.0 to 8.5 GHz	-41.3 dBm/MHz and 0dBm/ 50 MHz peak
5.	Singapore	3.4 to 4.8 GHz	-41.3 dBm and 0dBm/ 50 MHz peak for using mitigation techniques. Mitigation is not required in the sub-band4.2-4.8GHz until 2011.
		6.0 to 9.0 GHz	-41.3 dBm and 0dBm/ 50 MHz peak
6.	Japan	3.4 to 4.8 GHz	-41.3 dBm and 0dBm/ 50 MHz peak DAA required, but in 4.2-4.8 only from December 2008.
		7.25 to 10.25 GHz	-41.3 dBm and 0dBm/ 50 MHz peak
7.	Korea	3.1 to 4.8 GHz	-41.3 dBm and 0dBm/ 50 MHz peak DAA required, but in 4.2-4.8 only from July 2010.
		7.2 to 10.2 GHz	-41.3 dBm and 0dBm/ 50 MHz peak

Source: ACMA Report[19]

[19] http://www.acma.gov.au/webwr/_assets/main/lib311844/ifc1010_ultra%20wide%20band_consultation%20paper.pdf

4. Conclusions

It is widely anticipated[20] that wireless technology based on UWB radio can complement existing wireless technologies and has the potential to realize seamless connectivity with other communication infrastructure (i.e., provide users with their desired information on any devices anywhere and at anytime). This advantage of UWB technology is important even to cellular operators, as UWB technology may play a key role in the future wireless broadband network solution by providing enhancement and add-on functionality to next generation Mobile Termilanls such as high-data rate applications (e.g., audio/video multimedia data exchange, file sharing, etc.) and low-data rate applications with localization capabilities (e.g., sensor networks, information services, inventory tracking, etc.).

Few risks of UWB are observed, that:

- High power levels of UWB emissions pose a risk of causing interference to existing services. A proliferation of UWB emissions at high levels could adversely affect the coverage and service quality of a number of current “narrowband” systems. However, the power levels and short range over which low power UWB devices are designed to operate is unlikely to support significant wide area outdoor use. Example of services that could be affected include land mobile services, Global Positioning System (GPS), radio astronomy and Earth receive stations.

The remedy to the risks is the development of regulatory arrangements to support the use of UWB technology by short range applications that are generally used indoors or in handheld devices would reduce the potential risk of interference to radio communications services identified above.
A regulatory framework with detailed technical specifications and minimal administrative procedures is required in compliance to National regulations, which provides the regulation and mitigation necessary to protect existing radio communication services from the risk of interference from UWB devices.

There are some decision points that the framework maker is recommended to consider:

a. To decide on if to adopt licence-exempt or class licensing approach for operating UWB devices
b. To license UWB devices on a case-by-case basis?

[20] http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.85.5322&rep=rep1&type=pdf