Temporary Translation

Telecommunications Council
Information and Communications Technology Subcouncil
UWB Radio Systems Committee

Interim Report
Summary

Wednesday March 24, 2004

About UWB
Radio Systems

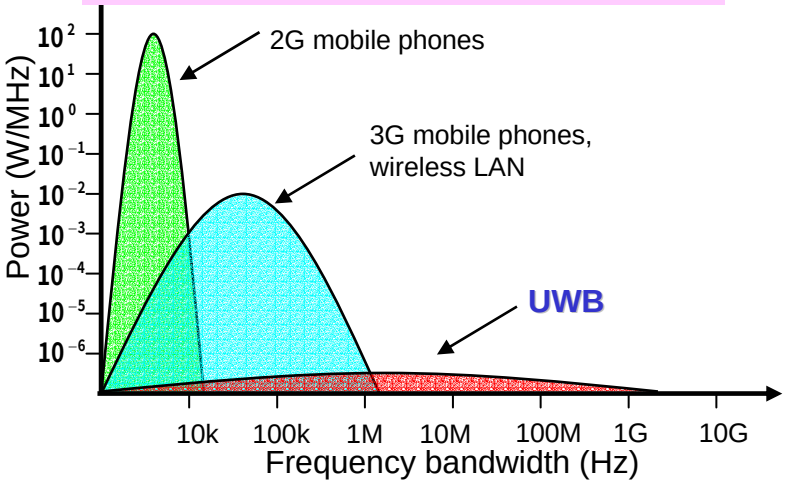
UWB (Ultra Wideband) Radio Systems

UWB radio systems can be used for high-speed data transmission (up to several hundred Mbps) over short distances (up to around 10 m) between computers and AV equipment.
UWB radio systems occupy an extremely wide frequency bandwidth of 500 MHz or more.

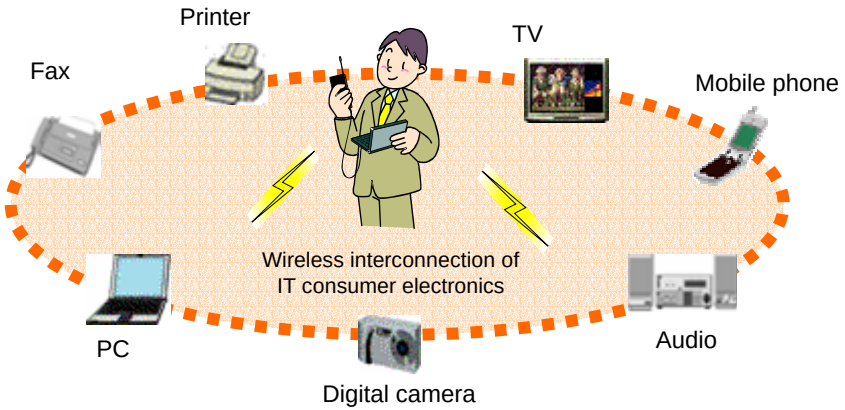
Features

- Extremely wide frequency bandwidth (hence the name “ultra wideband”)
  Normally occupies bandwidth of 500 MHz or more
- UWB radio signal overlaps existing radio systems
  Importance of investigating compatibility with a variety of other radio communication systems
- Very low transmission power relative to bandwidth (although still higher than Extremely Low Power Radio Stations in Japan)
  Tentative FCC provision: -41.3 dBm/MHz = 75 nW/MHz, i.e., 0.5 mW in the 7 GHz band
  (NB: Extremely Low Power Radio Stations = 0.37 nW at 322 MHz – 10 GHz)
- Transmission distances of up to around 10 m (based on emission power in FCC provision)

UWB versus other radio communication systems



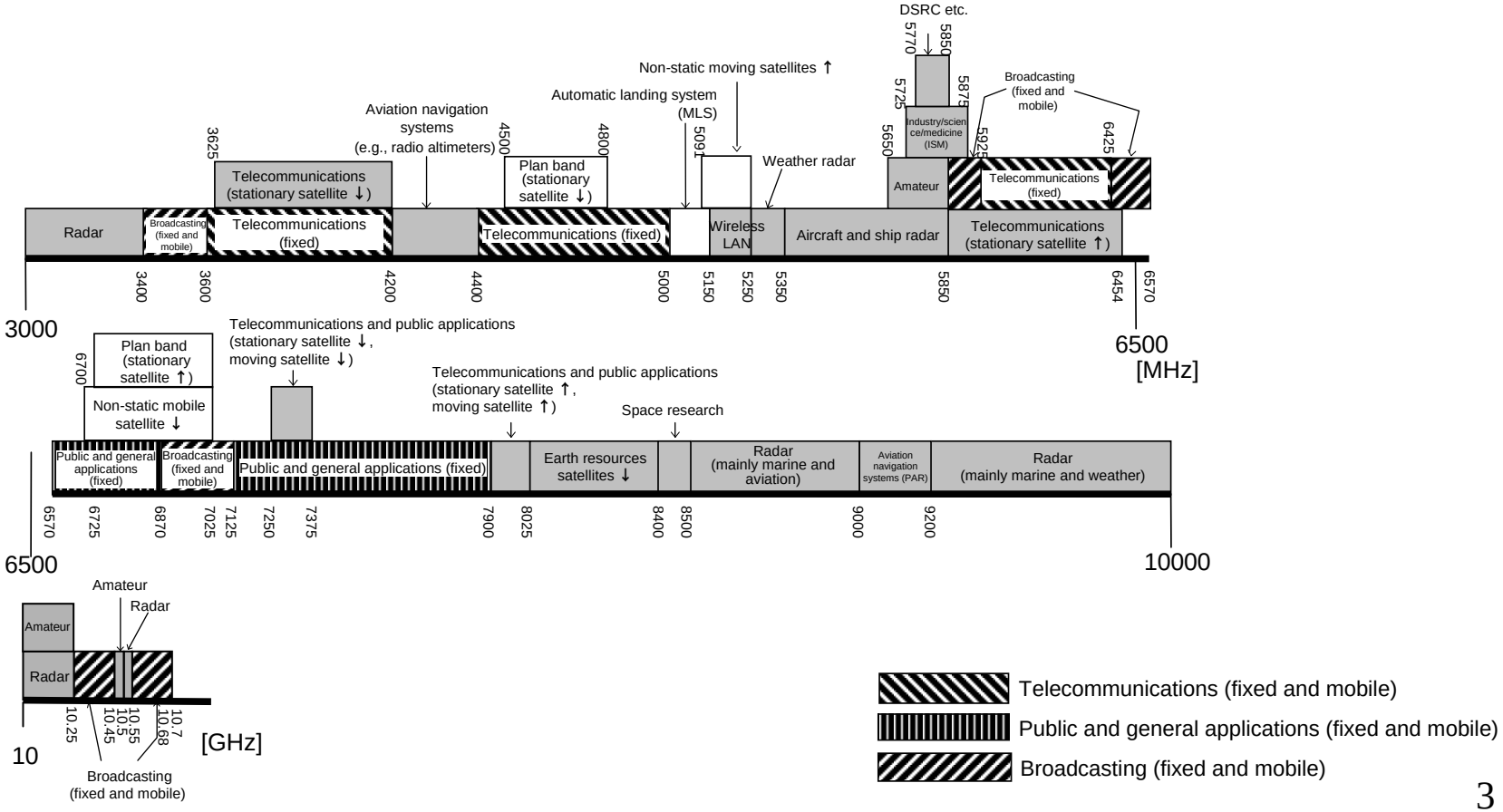
UWB applications



Current allocation of 3.1 – 10.6 GHz spectrum

From Inquiry Reason

In recent years, UWB radio systems have been a focus of attention as wireless technology for high-speed transmission over a short distance. UWB radio systems transmit digital pulses across a very wide spectrum of frequency bands wider than several GHz bandwidths, thus enabling 100-Mbps class high-speed transmission and precision radio location systems. **Upon introduction of UWB systems, it is necessary to deliberate on technical conditions, such as frequency sharing conditions with other radio systems using spectrums within the frequency bands to be used for transmission by UWB systems.**



Interim Report
Summary

Investigations in Japan and Overseas

○ Investigations in Japan

- Four working groups have been set up to investigate compatibility between UWB and other radio communication systems:
  the Compatibility Model Working Group, the Fixed-Broadcasting systems Working Group,
  the Radar-Aviation and Maritime systems Working Group, the Satellite-Low Power systems Working Group
- Comments were invited on the Draft Interim Report
  22 submissions received in the period 2 – 27 February 2004

○ UWB investigations overseas

(1) FCC (US Federal Communications Commission)
The FCC began conducting surveys and investigating measurement methods in 1998, based on the basic assumption that UWB should not cause interference or require interference protection. In 2002, the FCC issued tentative provisions.
The provisions for UWB communication applications are:
- Part 15.209 spurious emissions regulations apply to 3.1 – 10.6 GHz
- Emission power restricted below 3.1 GHz and above 10.6 GHz to prevent interference with other radio communications systems.

(2) IEEE (US Institute of Electrical and Electronics Engineers)
The IEEE is studying the feasibility of 802.15TG3a as a WPAN standard.
Candidates for standardization have been narrowed down to Multi-Band OFDM and DS-CDMA, but a final decision has yet to be made.

(3) ITU-R (International Telecommunications Union—Radio Communication Standardization Sector)
In July 2002, ITU-R set up Task Group 1/8 under Study Group 1 (Spectrum management) to investigate UWB technology, regulatory issues and compatibility with other radio systems.

Basic principles of compatibility model in Japan

(1) Radio spectrum is a finite resource. As such, radio spectrum usage should adhere to international systems of rules and should be carefully designed to avoid future problems.

(2) As yet, UWB stations do not belong to any designated service and the UWB format is not based on the Radio Regulations (RR) allocations. As such, it is not considered in compliance with stipulations.

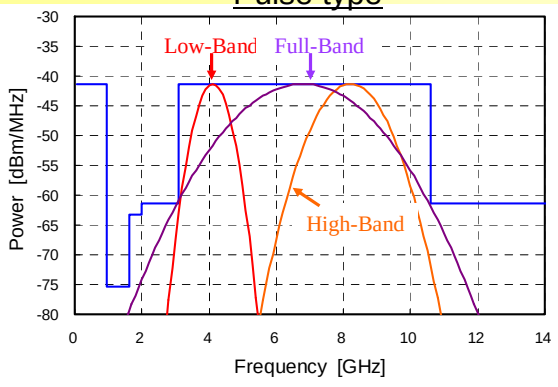
(3) The study of co-existence conditions is predicated on radio regulations (RR) 4.4 concerning interference.

[Radio Regulations. Section 4.4]
Administrations of the Member States shall not assign to a station any frequency in derogation of either the Table of Frequency Allocations in this Chapter or the other provisions of these Regulations, except on the express condition that such a station, when using such a frequency assignment, shall not cause harmful interference to, and shall not claim protection from harmful interference caused by, a station operating in accordance with the provisions of the Constitution, the Convention and these Regulations.

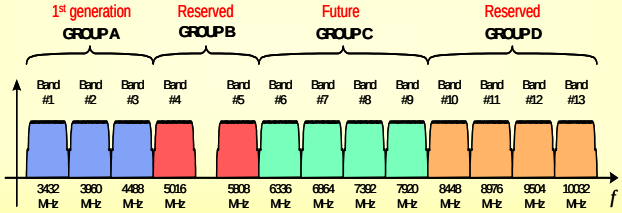
Proposed co-existence models

○ Different types of UWB radio systems under consideration

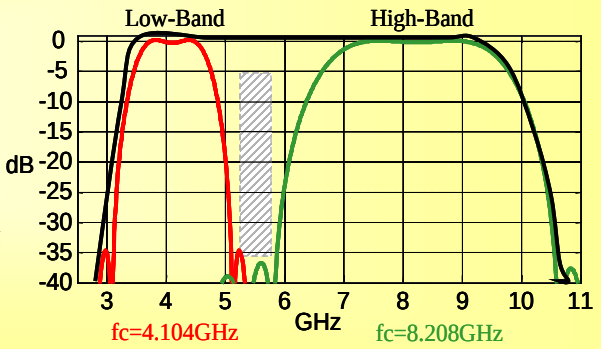
Pulse type



MB-OFDM type



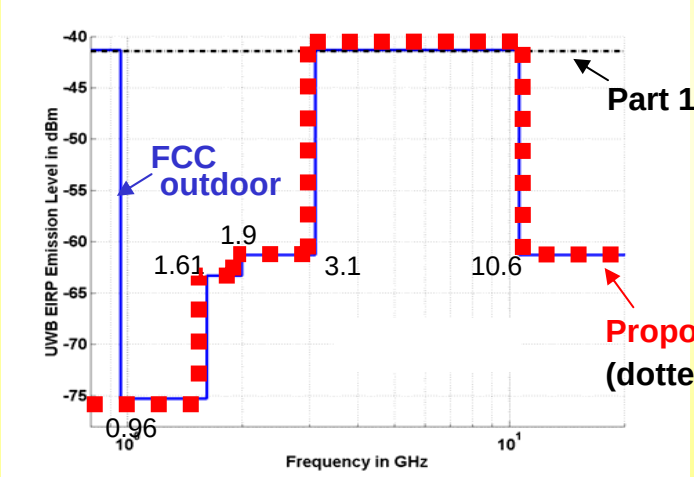
DS-CDMA type



○ Proposals for emission power mask

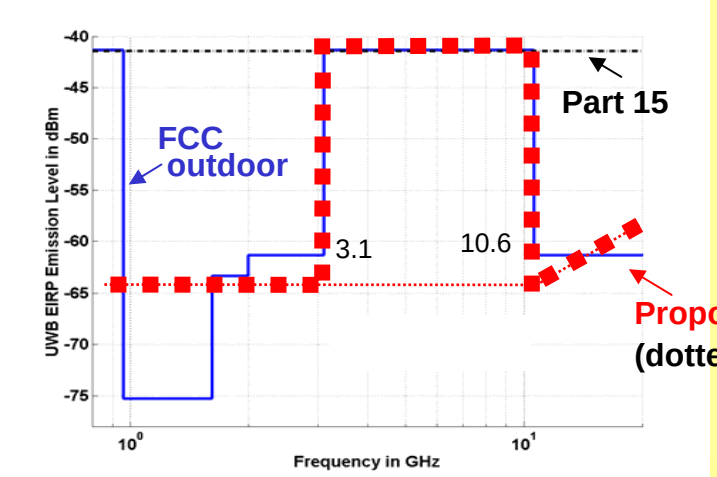
<Proposal 1>

Based on FCC Outdoor specifications



< Proposal 2>

Standards for Extreme Low Power Stations in Japan applied to portion of spectrum outside the range 3.1 – 10.6 GHz



Usage environment and interference between radio systems

○ Proposal usage environment

The main specifications of the proposal usage environment in the compatibility model are as follows:

- Indoor usage (wall attenuation: 12 dB)
- Usage density: 3,000 devices per km^2
- Active ratio: averaging 1% – 5% on per time basis
- Operation on board an aircraft, a ship or a satellite is prohibited

○ Interference with radio communications systems

The proposed compatibility model was subject to interference calculation under the following conditions to assess interference by a single UWB device with other radio communication systems (test details shown separately).

- FCC transmission power mask: -41.3 dBm/MHz at 3.1 – 10.6 GHz
- Free space propagation
- Wall attenuation: 12 dB (assuming indoor use; outdoor use: four times greater separate)
- Average power evaluation

Further Studies

(1) Harmonization with international studies is required, particularly with ITU-R and IEEE studies. Similarly, the outcomes of technical studies in Japan should be contributed in recommendations from organizations such as the ITU-R.

(2) Theoretical calculations based on the ITU-R recommendations and the proposed compatibility model incorporating FCC emission power proposals found that long separate distance or limitations on the number of devices would be required for compatibility between UWB and other radio communication systems, necessitating further studies as follows:

- Study of actual effect of UWB based on experimental data and simulations
- Detailed investigation to consider actual deployment of radio systems
- Other strategies for mitigating interference
- Review of emission power proposals

Summary of public comment submissions and future approach

- UWB will be a key technological component used in the construction of ubiquitous networking systems in the future. As such, it is important that UWB technology is institutionalize as soon as possible.
- UWB investigations should inquire carefully not on condition of introduction but in consideration of the international investigations.
- UWB interference issues should be considered in terms of a proper understanding of the technology on both sides, as opposed to the traditional approach to interference.
- UWB technology should be institutionalized step-by-step through a combination of intensive contributions to the ITU-R and usage limitations (such as in-home and regional limitations).
- Agreement with proposals for the general direction of investigations based on the need for international harmonization, studies of actual effects using experimental data and reviews of the emission power mask proposals.

Study of radio systems interference

Appendix

Interference between a single UWB device and various other radio communication systems was calculated under the following conditions.

- FCC emission power : -41.3 dBm/MHz (3.1 GHz – 10.6 GHz)
- Free space propagation
- Wall attenuation : 12 dB (assuming indoor use. Outdoor use: four times greater separate)
- Average power evaluation

	Main frequencies	Interference study
Fixed microwave systems	4 GHz, 5 GHz, 6 GHz, 6.5 GHz, 7.5 GHz, 11 GHz, 12 GHz, 15 GHz, 18 GHz	Separation of 80 m – 2.3 km is required in order to achieve the allowable interference level of kTBF-20dB as per ITU-R Rec. 1094-1. Minimum reception sensitivity is defined as noise + required C/N + fixed degradation. Composition of fixed degradation component is pre-determined; since UWB interference degradation cannot be included, thermal noise (kTBF) is used as the tolerance standard.
Broadcasting systems	3.5 GHz, 5.9 GHz, 6.5 GHz, 7 GHz, 10.5 GHz, 12 GHz, 13 GHz	Separation of 31 – 50 m required to achieve allowable interference level of kTBF-20db. Single entry separation is calculated for FPU (mobile Field Pick-up Unit used for live transmission on location) and SHF broadcasting (used for fixed household reception) only. For other types of fixed receiver (such as TSL and STL), the fixed microwave systems evaluation results are applied. Systems such as FPU would be used indoors and/or in close proximity to UWB, in situations with little wall attenuation. FPU could be used for (1) non line of sight, (2) wall reflection, or (3) communication between buildings. In terms of actual usage, in most cases a location plan and a frequency plan drawn up to enable prior testing. During actual relay transmission, the UWB device must not generate a signal that interrupts the broadcast. (UWB usage locations are not controlled so the broadcasters are not in a position to do anything about interference.) Some systems would have a bandwidth of under 1 MHz, so this should be tested too.
Amateur radio communication systems	5.6 GHz, 10 GHz	Separation of 29 – 92 m required to achieve a receiver sensitivity at the allowable interference level. Although frequencies are shared with radar and DSRC, the number of radars is relatively low, while DSRC is used in a limited locations. Interference problems would therefore be minimal. UWB, on the other hand, is normally used indoors so the potential for interference would be much greater.

	Main frequencies	Interference study
Radar and marine systems	1.6 GHz, 3 GHz, 9 GHz	Separation of 4 m – 188 km is required in order to achieve the allowable interference level of reception sensitivity –10 dB. In terms of service implications, it is impossible to prohibit on board a ship use of UWB devices. Tests for marine systems should therefore assume that UWB may be present on board. Given that some coastal stations use non-directional antennae, testing is also required in this area.
Aviation and weather radar systems	【Aviation systems】 1 GHz, 4,3 GHz, 9.4 GHz	Regardless of whether UWB is prohibited on board aircraft, further testing is required regarding the effects between external UWB devices (outside the aircraft) and on board radio equipment. In the United States, the RTCA (Radio Technical Commission for Aeronautics) has been studying on board UWB usage since January 2004, with findings due to be released by the end of 2005. Every effort should be made to keep abreast of such developments in international investigations. Testing is still in progress on separation distances for individual systems.
	【Weather radar systems】 5.3 GHz, 5.7 GHz	In peak power tests, Separation of 12 – 38 km is required in order to achieve the allowable interference level of receiver sensitivity –20 dB (average power tests not carried out). Some weather radar operate with an 0° angle of elevation. An input level greater than the minimum receiver sensitivity would cause a detection error.
Radio astronomy systems	3,260 – 3,267 MHz, 3,332 – 3,339 MHz, 3,345.8 – 3,352.5 MHz, 4,825 – 4,835 MHz, 4,950 – 4,990 MHz, 4,990 – 5,000 MHz, 6,650 – 6.675.2 MHz, 10.6 – 10.68 GHz	For a single UWB device, Separation required to satisfy ITU-R RA.769 at average power is 7.7 km – 23.6 km, taking wall attenuation into consideration. At a density of 3,000 devices per km^2, the emission power limit on each UWB device would need to be around –155 kBm/MHz. Radio astronomy systems observe in low noise level locations, so interference calculation in high noise locations are not considered necessary. Radio astronomy systems involve observation of signal levels below that of thermal noise. It is therefore unlikely that the interference threshold over the 2,000 second calculation period could be lowered below the ITU-R recommended RA.769 level. The ITU-R recommendation P.452 is considered a more realistic for radio astronomy systems compatibility evaluations than the ITU-R recommendation P.1411. A propagation model will need to be chosen at some point in the future. Given that the earth is spherical, the study would need to consider feasibility issues.

<table>
<tr><th></th><th>Main frequencies</th><th>Interference study</th></tr>
<tr><td>Satellite</td><td>• Mobile satellite
• Stationary satellite
• Broadcasting satellite
• Earth exploration satellite (including feeder links)

1.5 GHz, 2. GHz,
2.5 GHz, 4 GHz,
6 GHz, 7 GHz,
8 GHz, 10 GHz,
11 GHz, 12 GHz,
13 GHz, 14 GHz,
17 GHz, 19 GHz,
29 GHz</td><td>Downlink: separation of 1 – 925.8 m required to achieve allowable interference level of kTBF – 20 dB (for single UWB device).
For uplink and downlink, compatibility study required into aggregate interference from all applications including UWB in a footprint (primary applications excluded).
Where UWB is used indoors, it is unlikely to exist in the direction of maximum gain of a terrestrial station antenna. However, UWB may exist in locations very close to this direction, even when the building does not affect transmission.
BS antenna tend to be installed on verandas and at other location that could potentially be in close proximity to UWB. Given the usage environment, the wall attenuation is unlikely to provide much. Receiver could well suffer from UWB interference from neighboring dwellings.
Sea rescue systems use at 1.5 GHz , which is of vital importance with respect to human life. Interference study is already underway.
Some systems use bandwidths under 1 MHz; a study is required into the effect on narrowband carriers using less than 1 MHz.</td></tr>
<tr><td></td><td>【Earth exploration satellites (on-board passive sensors)】</td><td>The table below shows the maximum number of UWB devices and density for an allowable tolerance level as per the ITU-R recommendation SA.1029-2 for EESS (passive).
<table>
<tr><th>Outdoor</th><th>1.4GHz</th><th>2.7GHz</th><th>4.3GHz</th><th>7GHz</th><th>10.7GHz</th></tr>
<tr><td>Number of UWB devices</td><td>4,642</td><td>1,174</td><td>6</td><td>21</td><td>2,830</td></tr>
<tr><td>Density (devices per km^2)</td><td>2.3</td><td>0.4</td><td>0.0</td><td>0.0</td><td>2.8</td></tr>
<tr><th>Indoor</th><th>1.4GHz</th><th>2.7GHz</th><th>4.3GHz</th><th>7GHz</th><th>10.7GHz</th></tr>
<tr><td>Number of UWB devices</td><td>73,578</td><td>18,604</td><td>98</td><td>335</td><td>44,855</td></tr>
<tr><td>Density (devices per km^2)</td><td>36.3</td><td>5.8</td><td>0.1</td><td>0.1</td><td>44.4</td></tr>
</table></td></tr>
<tr><td></td><td>【GPS】
1.5 GHz</td><td>Separation of 0.5 – 7.3 m required to achieve the allowable interference level of kTBF –6dB.
The accuracy of GPS in mobile telephones and other devices that perform measurements indoors and in close proximity to UWB would be affected.
At the second meeting of ITU-R TG 1/8, Qualcomm submitted a proposal on allowable transmission power with a separation distance of 1 m. Investigations are continuing.</td></tr>
</table>

	Main frequencies	Interference study
DSRC	5.8 GHz	Separation of 0.5 – 11 m is required when the allowable interference level is the reception sensitivity. If the inside of a vehicle is assumed to be indoors, UWB devices can be brought inside. Moving vehicles with UWB devices can potentially impact on a wide range of other radio communication systems. As with aircraft, usage within vehicles will need to be restricted. The types of UWB devices that are build in vehicles can be restricted, but it is more difficult to prevent UWB devices being taken into vehicles. Further investigation is required.
Mobile telephones	800 MHz, 1.5 GHz, 2 GHz, 1.9 GHz (PHS)	Separation is 181.7 m – 3.92 km for base stations (allowable interference level = kTBF – 20dB) and 6.4 – 49.5 m for mobile stations (allowable interference level = kTBF –10dB). While separation for mobile stations may appear short, it is envisaged that UWB devices and mobile phones would be used in the same personal area, with the potential for mobile stations to approach UWB devices to within one meter in an indoor setting. Some form of effective interference mitigation strategy for compatibility. Interference from neighboring cells can be controlled where identical systems are involved, but not when the systems differ from one another. For this reason, kTBF should be used as the base standard for compatibility with mobile phones. Since PDC and PHS use channel bandwidth of less than 1 MHz, an investigation into emission power mask regulations under 1 MHz is required. An ITU-R working document describes IMT-2000 (using the Monte Carlo method) and UWB compatibility test results, suggesting that the FCC mask should be reduced by a further 10 dB in the 2 GHz band. In the near future, systems included in frequency allocation plans should be incorporated into testing and experimental programs so as to prevent any problems with 4G mobile communication systems and ubiquitous networking devices.
Radio access	5 GHz	Separation of 15.6– 61.9 m required to achieve allowable interference level of kTBF – 10dB. In order to prevent reception errors in wireless LAN systems, it may be necessary to impose limits such that the maximum UWB transmission peak power does not result in a received signal level above the wireless LAN CS threshold: 1. Separation between UWB and wireless LAN to ensure that the UWB peak power level received by a wireless LAN does not exceed the CS threshold for the LAN 2. Compatibility with wireless LAN systems requires collision avoidance using CS to be built into UWB (as with 11a).