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Technical Report

Electromagnetic compatibility and Radio spectrum Matters (ERM); Short Range Devices (SRD); Technical characteristics for SRD equipment using Ultra Wide Band Sensor technology (UWB); System Reference Document Part 3: Location tracking applications type 1 operating in the frequency band from 6 GHz to 9 GHz for indoor and outdoor usage

Reference

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Contents

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Foreword

This Technical Report (TR) has been produced by ETSI Technical Committee Electromagnetic compatibility and Radio spectrum Matters (ERM).

The present document is part 3 of a multi-part deliverable covering Electromagnetic compatibility and Radio spectrum Matters (ERM); Short Range Devices (SRD); Technical characteristics for SRD equipment using Ultra Wide Band Sensor technology (UWB) as identified below:

Part 1: "Building material analysis and classification applications operating in the frequency band from 2,2 GHz to 8 GHz";

Part 2: "Object Discrimination and Characterization applications operating in the frequency band from 2,2 GHz to 8 GHz";

Part 3: "Location tracking applications type 1 operating in the frequency band from 6 GHz to 9 GHz for indoor and outdoor usage";

Part 4: "Object identification for surveillance applications operating in the frequency band from 2,2 GHz to 8 GHz";

Part 5: "Location tracking applications type 2 operating in the frequency band from 6 GHz to 9 GHz for indoor and outdoor usage".

The basic differences of the present document to the published version TR 102 495-3 v 1.1.1 are:

- In the published version operation is limited to indoor usage. The present document describes mixed indoor and outdoor usage because there is an increasing demand for such applications (i.e. location tracking in logistic warehouses, manufacturing facilities, petrochemical refineries).
- For a number of these applications there is a demand for increased range as well as for usage under more difficult operating and environmental conditions. In consequence, a slightly higher power level (i.e. an increase of 10 dBm/MHz) is proposed in conjunction with the mitigation factors as defined in clauses 6 and C.3.

Introduction

Ultra Wide Band (UWB) technology enables a new generation of Location Tracking devices and opens new markets with very different applications. UWB radio location devices with an operating bandwidth of several GHz allow centimetre-level localization and positioning even in the presence of severe multipath effects caused by walls, furniture, etc.

It is a viable positioning technology that meets industrial requirements in the following markets:

1) Healthcare.

2) Workplace/Smart Office.

3) Public buildings.

4) Security and Safety (e.g. in the petrochemical industry).

5) Defence training.

6) Entertainment and Sports.

7) Logistics, warehouses.

8) Manufacturing assembly lines.

9) Automotive, rail, aviation.

The purpose of producing the present document is to lay a foundation for industry to quickly bring innovative and useful products to the market while avoiding any harmful interference with other services and equipment.

1 Scope

The present document defines the requirements for radio frequency usage for Ultra Wide Band (UWB) location tracking devices. These devices are operating in the frequency range from 6 GHz to 9 GHz and using a fixed infrastructure. It will include applications from all different markets (see list of markets in introduction) for indoor and outdoor usage.

UWB based location tracking applications, under the scope of the present document, require small, lightweight tags which are attached to the objects to be located, or are carried by personnel.

The present document includes necessary information to support the co-operation between ETSI and the Electronic Communications Committee (ECC) of the European Conference of Post and Telecommunications Administrations (CEPT), including:

- Detailed market information (annex A).
- Technical information (annex B).
- Expected compatibility issues (annex C).

2 References

For the purposes of this Technical Report (TR) the following references apply:

NOTE: While any hyperlinks included in this clause were valid at the time of publication ETSI cannot guarantee their long term validity.

[1] CEPT/ECC Report 64: "The protection requirements of radiocommunications systems below 10,6 GHz from generic UWB applications", Helsinki, February 2005 .

NOTE: Avalaible at http://www.ero.dk/doc98/Official/pdf/ECCREP064.pdf.

[2] CEPT/ERC Report 25: "The European table of frequency allocations and utilisations covering the frequency range 9 kHz to 275 GHz Lisboa January 2002 - Dublin 2003 - Turkey 2004 - Copenhagen 2004".

[3] Document TG3#7-19R0 ("Effects of PSD limits on UWB positioning systems"), submitted to ECC TG3 meeting, Brest, 1-3 March 2005.

[4] FCC 03-33: "Revision of Part 15 of the Commission's Rules Regarding UWB Transmission Systems".

[5] ECC/DEC/(06)04: "ECC Decision of 24 March 2006 on the harmonised conditions for devices using UWB technology in bands below 10.6 GHz".

[6] Revised Terms of reference for ECC TG3 (July 2006).

[7] Report developed by the European Conference of Postal and Telecommunications Administrations (CEPT) in response to the European Commission (EC) under the Mandate dealing with the harmonized technical conditions for the use in the European Union of the mitigation techniques for UWB applications.

[8] ITU-R, Radio Regulation, Geneva, 2004.

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the following terms and definitions apply:

activity factor: user dependent device activity over one day

light licensing: individual regulatory approval (or notification duty) required for each specific installation based on location and scope

Low Duty Cycle (LDC): reflects the effective transmission time ratio which is system inherent and not user dependent

range resolution: ability to resolve two targets at different ranges

3.2 Symbols

For the purposes of the present document, the following symbols apply:

c	velocity of light in a vacuum
δR	range resolution or multipath rejection resolution
dBm	deciBel relative to 1 mW
T_P	pulse width

3.3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

2D/3D	Two Dimensional/Three Dimensional
CEPT	Conference Europeenne des Administrations de Postes et des Telecommunications
ECC	Electronic Communications Committee
ERC	European Radiocommunications Committee
ERM	Electromagnetic compatibility and Radio spectrum Matters
GPS	Global Positioning System
ITU	International Telecommunication Union
LAN	Local Area Network
LDC	Low Duty Cycle
MoU	Memorandum of Understanding
OoB	Out of Band
PRF	Pulse Repetition Frequency
PSD	Power Spectral Density
RF	Radio Frequency
SRD	Short Range Device
ToR	Terms of Reference
UWB	Ultra Wide Band

4 Executive summary

The present document describes a new generation of devices using Ultra Wide Band Sensor technology for location tracking applications. It is an amendment in comparison with the location tracking devices described in part 3 of the present document. The new aspects are as follows:

- There is a growing demand for location tracking applications with outdoor or mixed indoor and outdoor usage, i.e. location tracking in logistic warehouses, manufacturing facilities, petrochemical refineries, public places or entertainment areas. Therefore, usage of such devices should also be allowed outdoor.

- For several applications there is a demand of increased range as well as for usage under more difficult operating conditions and environments. In consequence, a higher power level is proposed in combination with specific mitigation factors for these new location tracking applications.

In UWB location tracking, small, mobile tags, operating as either transmitters or receivers, or both, are attached to the objects to be located, or are carried by personnel. A network of reference stations around the area to be covered communicate with the tags. By analysing, e.g. the time-of-arrival and/or angle-of-arrival of the radio signal relative to the known reference stations, the 2D/3D position of the tag can be found. Typically, the required range between a tag and a reference station might be up to 150 m, depending on the area to be observed.

There is evidence that these devices can address versatile industrial requirements in many different markets and therefore, a socio-economic benefit is given.

It is also possible that such a system will significantly enhance the security and safety of persons monitored in different applications such as evacuation, emergency response in petrochemical plants, hazardous environments and healthcare.

A high precision in range measurement is required. This means that the required signals necessarily demand short pulse length resulting in a high bandwidth to provide the required accuracy.

It is expected and understood that a critical regulatory foundation for the proposed increased power levels for indoor operation and the proposed outdoor usage will be a form of national "light licensing", where usage is permitted by approval based on the location and situation of the deployment site.

4.1 Status of the present document

The present document has been created by ERM TG31C. It was approved by ERM_RM at its 35th meeting. It is to be forwarded to ECC TG3 for their studies and considerations according to clause 8.

The preent document will be submitted to ERM #31 in March 2007 for approval for publication.

4.2 Market information

For detailed market information, see annex A.

4.3 Technical system description

For a detailed technical information, see annex B.

5 Current regulations

Location tracking devices which are only for indoor operation are covered by the Generic UWB decision [

] in Europe.

However, there are neither current regulations permitting the operation of UWB location tracking outdoor nor in road and rail vehicles or in aircraft and other aviation applications available.

The FCC has released an UWB regulation which included UWB imaging devices in 4/2002 and revised it in 03/2003 [4].

6 Proposed regulations

Based on the needs of the intended applications described in the scope of the present document, the following limits are proposed as input values for the ongoing discussions and considerations in ECC TG3. The tables below describe the proposed changes only, all other aspects remain the same as the current decision.

All the proposed changes in tables 6.1 and 6.2 have a maximum limit of 2,5 % duty cycle.

Table 6.1: Proposed regulation for indoor equipment

Frequency	Area of operation	Maximum Average power density (EIRP) (dBm/MHz)
6 GHz to 6,4 GHz	Indoor	-41,3
6,4 GHz to 8,5 GHz	Indoor	-31,3
8,5 GHz to 9 GHz	Indoor	-41,3

This proposed change will enable cost effective location tracking solutions by enabling increased range and lower infrastructure costs in challenging environments in manufacturing, logistics and healthcare.

Table 6.2: Proposed regulation for outdoor equipment under individual light licensing

Frequency	Area of operation	Maximum Average power density (EIRP) (dBm/MHz)
6 GHz to 6,4 GHz	Outdoor	-51,3
6,4 GHz to 8,5 GHz	Outdoor	-41,3
8,5 GHz to 9 GHz	Outdoor	-51,3

The proposed change for outdoor usage will enable a number of industrial and professional markets to deploy successful applications that will deliver significant economic benefit to European business.

Design requirement:

- All objects or persons being traced must use tags.
- For all devices with impulsive UWB modulation, the PRF shall not be less than 1 MHz (according to ECC Decision [5]).

The devices permitted under the ECC decision for UWB [5] are for indoor usage and exempt from individual licensing.

They operate on a non-interference and non-protected basis.

It is proposed that the same rules as for indoor usage should apply for usage in road and rail vehicles, in aircraft and other aviation vehicles.

For outdoor usage the devices should operate under an appropriate licensing.

7 Main conclusions

Ultra wideband technology enables a new generation of location tracking devices. The short pulses used by UWB location devices enable accurate signal measurements, allowing centimetre-level positioning even in the presence of severe multipath interference (caused by reflections off doors, windows, walls and furniture).

These devices can address versatile industrial requirements in many different markets and therefore, a socio-economic benefit is given.

It is also possible that such a system will significantly enhance the security and safety of persons monitored in different applications such as health care and hazardous environments.

A high precision in range measurement is required. This means that the required signals necessarily demand short pulse length resulting in a high bandwidth to provide the required accuracy.

8 Expected ECC and ETSI actions

Mandate M/329 was received by ETSI, calling for release of Harmonized Standards for UWB.

ECC-TG3 continues the work under revised ToR conditions [6]. This work includes finding a regulatory solution for UWB usage in road and rail vehicles, in aircraft and other aviation vehicles as well as for outdoor installations for location tracking.

ETSI requests ECC to consider the present document, which includes necessary information under the MoU between ETSI and the ECC issuing regulations for the proposed location tracking device types.

ETSI asks CEPT-ECC to perform the relevant compatibility studies to determine whether the emissions described in the present document are appropriate to protect other radio services and to provide the practical measures to ensure the protection of other radio services in the anticipated bands and emission levels.

A harmonized European standard (EN 302 500) for UWB location tracking equipment was published in February 2007. It is envisaged that this standard will be revised in ERM TG31C.

Since the new location tracking devices are not fundamentally different from the first generation, time-to-market of these devices is possible to happen as soon as the middle of 2007. Therefore, ECC is requested to provide a finalized regulatory solution by no later than middle of 2007.

Annex A: Detailed market information

A.1 Range of applications

Applications of UWB location tracking technology are many and varied. Within hospitals, equipment, patients and doctors can be located quickly to speed up response to an incident. In the workplace, computers and communications systems can be shared between personnel, and automatically configured for a particular user as they walk up to equipment. In high-security environments, authorized personnel can be tracked, and unauthorized persons quickly identified when passive sensors (e.g. infra-red sensors) detect the presence of a person who is not located by the tracking system. Additionally, in industrial and agricultural environments the system can be used to track products through an assembly line and to monitor animal behaviour (e.g. in the dairy industry).

The list below indicates some of the many applications of UWB Location Tracking technology in each of a number of environments - it is in no way intended to be an exhaustive list:

- Healthcare:
  - Streamlining hospital processes (locating staff, finding wandering patients).
  - Asset tracking and management (finding equipment, evaluating equipment usage).
  - Safety (panic alarms with position-finding capability).
- Industrial and logistics asset tracking:
  - Location tracking of high value assets, pallets or fork-lifts.
  - Tracking is not limited to one building but to every possible location in the whole area., therefore outdoor usage is necessary.
  - Halls are typically very large and installation of infrastructure (network, cabling, sensors) is very expensive. Therefore an increase of ranging would be very beneficial. It can be shown that the required number of base stations increases rapidly as the PSD limit decreases.
- People and asset tracking in public places:
  - Security applications. Since September 11th security is a No 1 topic in public places. "Command and Control" systems, that know where operational personnel are, raising alarm if they enter critical zones, integration with camera tracking, resource management for rapid response are examples of applications where mixed indoor/outdoor usage is necessary.
  - Collision avoidance between container wagons and aircraft.
  - Workflow management and quality control: There are very high requirements regarding who is allowed to execute maintenance work at an aircraft. Location tracking enables control of these requirements in real time and the documentation of complete work steps.
- Safety applications in hazardous environments:
  - To know where people are in emergency situations. For example there are rules that in a catastrophic case everybody should leave an oil platform within 20 minutes. Real time location tracking can support this either in training situations or in a real situation, therefore outdoor usage is necessary.
  - Control the workflow of employees. For example there are rules how long employees are allowed to work in high radiation environments in a nuclear plant. The integration of a tracking system with a radio-dosimeter enables accurate and reliable tracking of the workers in radioactive areas gathering dosimeter readings.

- Entertainment and Sports applications:
    - On stage location: Information about the location of the artists is desired in theatres and movie production enterprises. Based on given localization information it is possible to control e.g. spot beams or camera devices, therefore outdoor usage is necessary.
    - Location tracking in sport events or training sessions. For example in a ice hockey game, it is useful to get movement information of all players, puck and ice officials relative to and including the playing surface of the rink, players boxes, and penalty boxes.
- Location tracking in/around cars:
    - Differentiation in-car/out.
    - Intention.
    - Distance.
    - Keyless entry.
- Location tracking in public transport:
    - In-vehicle ticket/passenger checks.

As can be seen from the above, the markets are exclusively professional/industrial use. There is no evidence currently that UWB location tracking will have any traction at all in consumer applications as other technologies (e.g. Galileo, mobile cell coverage) are ideal for these markets. The necessity for fixed infrastructure for UWB technology is not considered marketable to the consumer sector.

A.2 Market size and value

As described above, UWB location tracking systems will have a direct impact in a number of markets, such as healthcare, workplace, security, entertainment, defence training, warehousing, and manufacturing. The market size estimates in figure A.2.1 show the projected combined value of hardware, software and professional services for the UWB Location Tracking industry from 2005 to 2012 (with a combined market size estimate of 2 700 Mio € in 2012). Development of this market will depend on the high accuracy and reliability provided by UWB systems as well as the infrastructure cost per square metre and the range of applications which can be addressed. The values shown in blue depict the market sizes based on the current standard. The delta in purple shows the effect of extending the standard according to this proposal. Figure A.2.2 shows the projected tag densities across Europe as companies deploy UWB location tracking to improve their businesses. The blue and purple values represent the current standard and the delta resulting from the introduction of this proposed amendment.

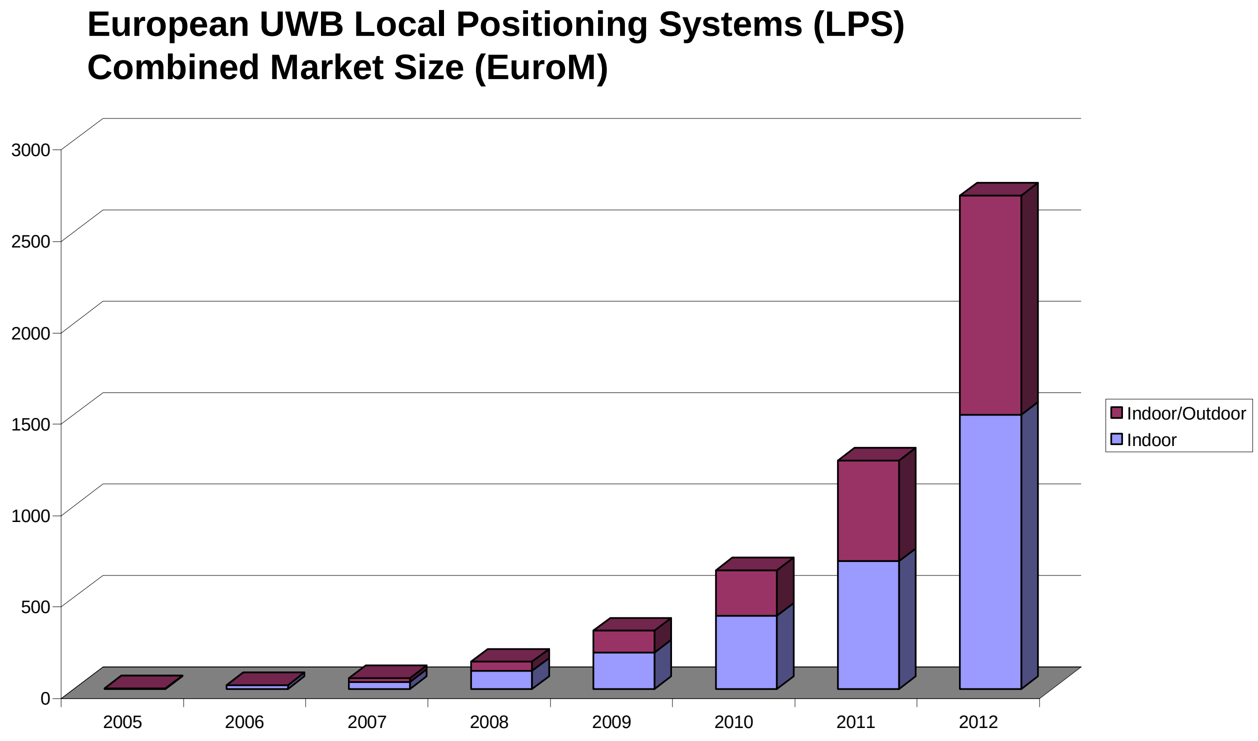

Figure A.2.1: European Location Tracking Systems Combined Market Size per year (2005-2012) in millions of Euros

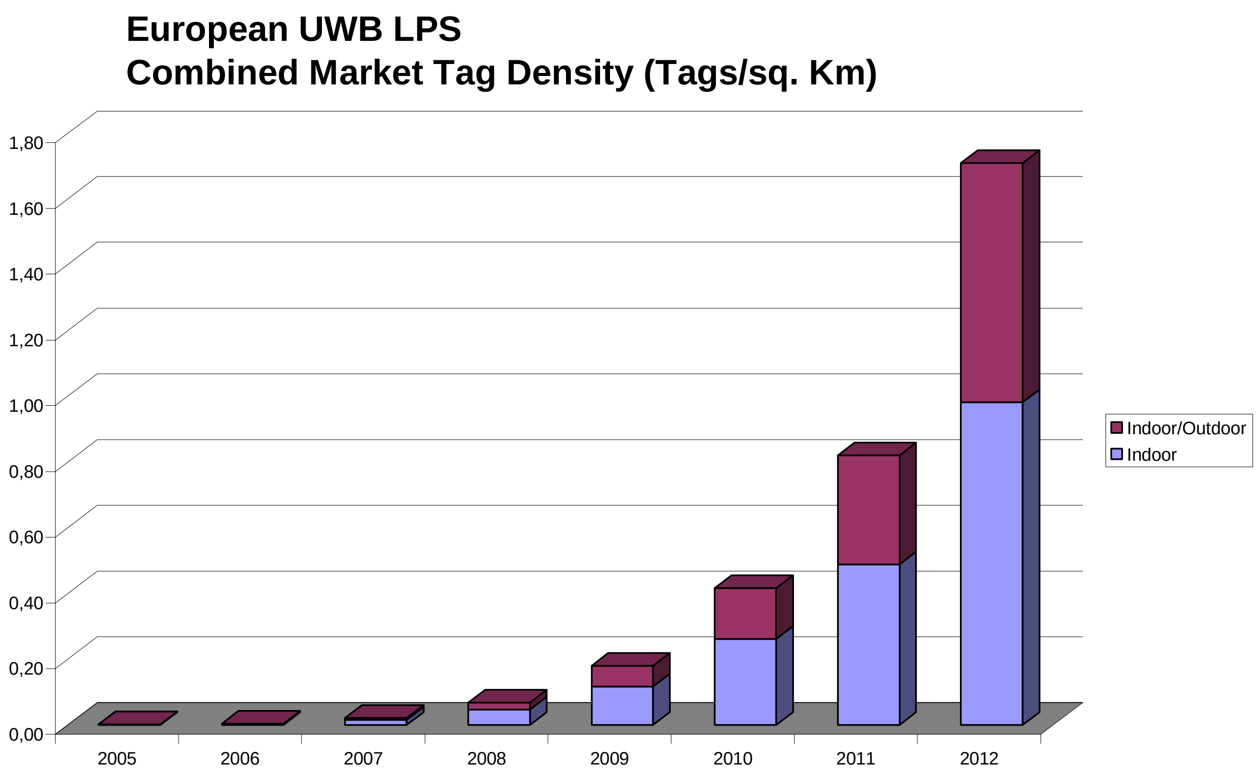

Figure A.2.2: European Local Positioning Systems cumulative tag density (2005-2012) in tags per square Kilometer

A.3 Traffic evaluation

The likely modes of deployment and activity factors of UWB Location Tracking systems are discussed below:

- UWB location tracking systems provide a powerful capability for industry to build automated process management and resource management systems. There is no equivalent technology that can match the accuracy and reliability of UWB for location tracking in a number of key applications.
- These industrial and professional applications will track people, assets and critical resources.
- Given that the user base of UWB location devices will be limited to certain professional groups, rather than the public at large, the **expected number of location tracking devices will be relatively low**. It is very unlikely that the worst-case numbers of active devices used in previous UWB compatibility studies for UWB communications devices will ever be approached by UWB location systems.

Location system devices are generally required to be very low powered and zero-maintenance (with battery lifetimes of years), and so tend to have **relatively low to very low duty cycles** and therefore a reduced risk for harmful interference [7]**.** Assuming a typical pulse train length of 25 milliseconds (used by a representative device) and a location update frequency of 1 Hz, the LDC of a device in operation is typically 2,5 %.

Another example is a commercial LDC UWB device whose design is based on FCC rules, Part 15,250 (5,925 GHz to 7,25 GHz), transmitting typically 100 pulses, each of about 2 ns duration, as a single burst each second, with a PRF of 1 MHz. The resulting envelope duty cycle (ratio of burst length and burst interval) and actual transmission duty cycle (ratio of "RF on-time" and "RF off-time") of this commercial device is thus ~0,01 % and 0,00002 %, respectively.

NOTE: Additional sharing information considering low duty cycles, a low average activity factor and the indoor/outdoor attenuation is given in table C.3.1

In summary, therefore, UWB location tracking systems are primarily to be used by professional users, and have relatively low to very low activity factors.

Annex B: Technical information

B.1 Detailed technical description

Small UWB transmitter tags are attached to the objects to be located, or are carried by personnel. The signals emitted by these tags are detected by a network of receivers placed at known, fixed points around the area to be instrumented. By detecting the signal at a number of receivers, and analysing the time-of-arrival and/or angle-of-arrival of the radio signal, the 3D position of the tag can be found.

NOTE: Other location system architectures are possible, in which the UWB transmitters are fixed and the receivers are mobile (much like the wide-area GPS system), but the general properties of the systems remain the same. However, mobile UWB transmitters are usually favoured over mobile UWB receivers, because UWB receivers tend to be more power-hungry than UWB transmitters, and power on the mobile units is limited.

A diagram illustrating the components of a typical UWB location tracking system is shown in figure B.1.1.

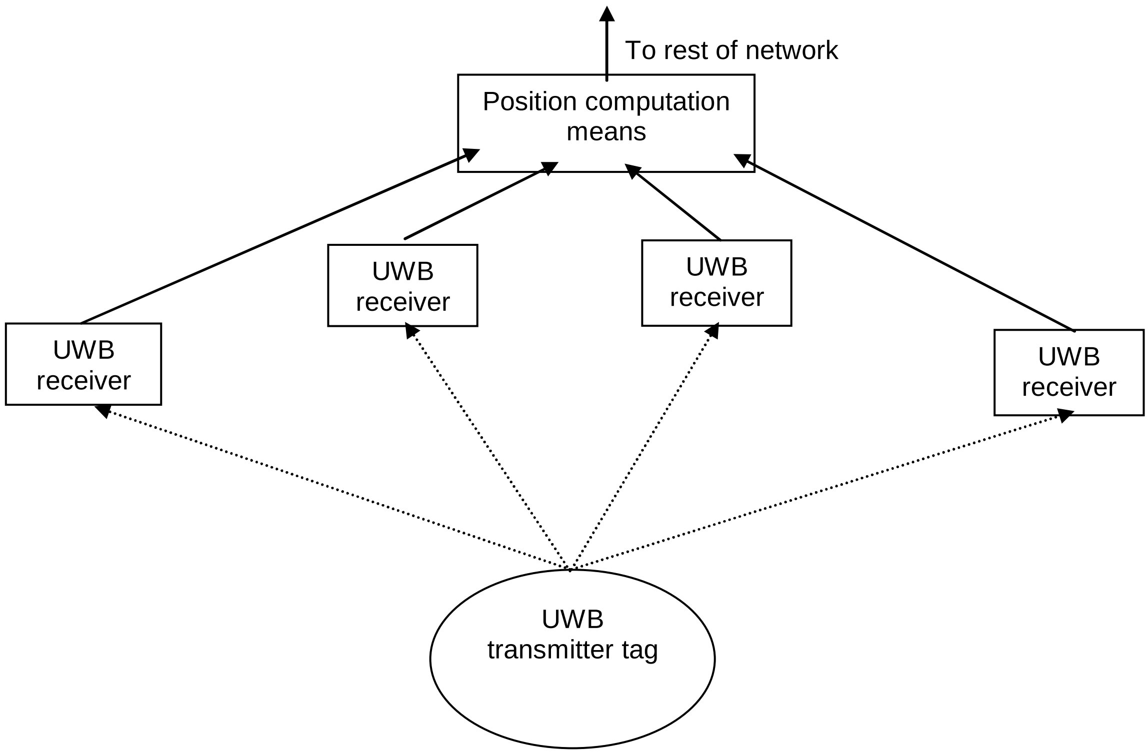

Figure B.1.1: Components of a typical UWB location tracking system

Typically, the range between a tag and a receiver might be between 10 m to 100 m, depending on the level of building obstruction between the two. A large building, such as a hospital, could be covered by a set of receivers placed with roughly the same density as a wireless LAN installation.

It is likely that the range of frequencies and power levels used for UWB tracking systems will be closer to those of communications systems than those of imaging systems. For example, location systems already on the market in the US use spectrum above 5 GHz, whereas UWB imaging systems might operate in the region below 1 GHz. However, user demographics, deployment density, activity factors and modulation schemes will be significantly different for UWB location tracking systems and UWB communications systems.

Since the tracking system devices cannot be located in the absence of supporting surveyed infrastructure, the usefulness of such devices would not be limited if UWB location tracking transmitter activity were tied to particular sites. This step would decrease the risk of uncontrolled proliferation of transmitters and would stop transmitter activity when it was not required (i.e. outside of the operating range of the infrastructure). One way of implementing a system that conformed to this requirement would be to ensure that UWB location tracking transmitters do not transmit if they fail to receive a "heartbeat" signal from the sensor infrastructure. The heartbeat signal could be transmitted in one of a number of ways: over a UWB channel, a conventional RF channel, an infra-red channel, etc. In this way, an UWB tag can also support two way control/communication mechanism, such that the infrastructure can send control data to the tag, e.g. to alter the tag's operating behaviour. By ensuring (during the installation of the location system infrastructure) that the heartbeat signal was not detectable outside the building in which the system was operating, one could assure that UWB transmitter tags meet the aforementioned requirement.

B.2 Technical justification for spectrum

UWB Location tracking technology present a viable solution because of the reliable operation, precision and functionality for the applications as noted under "Introduction" such as:

- Healthcare.
- Workplace/Smart Office.
- Public buildings.
- Security.
- Defence training.
- Entertainment.
- Logistics, warehouses.
- Manufacturing assembly lines.

and in more detail as listed under clause A.1 "Applications".

A number of radio technologies have been developed for locating objects in the wide area to an accuracy of a few metres (such as GPS, Galileo). For a number of reasons, these systems are of little value indoors (and in other high-multipath environments):

- The radio signals used by satellite and ground-based systems do not penetrate the structures of buildings sufficiently.
- Multipath effects within buildings, and the "urban canyon" environments that surround them, substantially degrade the nominal accuracy of present tracking systems.
- At best, in ideal conditions, the accuracy of these existing systems is no better than a few metres. Several applications of in-building tracking technology require knowledge of where a person or object is to the granularity of a room or a floor within a building. Even under ideal conditions, it is questionable whether wide-area systems can provide the required accuracy: if a person stood next to a wall, a location system with an accuracy of a few metres could easily record them as being on the other side of the wall, in another room. Once the nominal accuracy of the wide-area systems is degraded due to attenuation and multipath effects, it becomes clear that they cannot support indoor applications.

In contrast, a UWB location tracking system can ideally position objects within a building to an accuracy of 10 cm to 15 cm in 2D/3D - the wide bandwidth of UWB signals can significantly improve the system's robustness to in-building multipath effects.

B.2.1 Technical justification for proposed power levels

UWB positioning technologies are very sensitive to the permitted PSD limit because they can only make use of a small fraction of the energy emitted by a UWB transmitter: that portion which reaches a receiver via the direct path.

Operations under outdoor or harsh environmental conditions require a higher power spectral density than for the location tracking devices of the first generation. Field measurements have verified the proposed PSD limits in clause 6.

The resulting maximum outdoor operating range is up to 150 metre. The indoor operating range is approximately doubled with the proposed PSD limits compared with the first generation devices.

The proposed limits will enable a UWB positioning system industry to develop and have a much wider addressable market. On the contrary, lower PSD limits will increase the amount of required infrastructure to the point where UWB positioning technology will not be adopted.

The Out of Band (OoB) emissions limits for emissions are defined according to the ECC decision for UWB [5].

Table B.2.1: OoB emission limits

Frequency Band (GHz)	Maximum mean e.i.r.p. density (dBm/MHz)-
Below 1,6	-90
1,6 to 2,7	-85
2,7 to 6	-70
9 to 10,6	-65
Above 10,6	-85

The Out-of-Band emission limits given above take into consideration both the requirement for protection of existing services in those regions of the radio spectrum, and the feasibility of taking accurate measurements of very low-level spurious emissions (particularly as the measurement noise floor of test facilities rises with increasing frequency).

B.2.2 Technical justification for bandwidth

UWB location tracking devices operate by radiating a short pulse from a transmitter which is then detected by one or more receivers. By measuring the time-of-arrival (or time-difference-of-arrival) of the signal at one or more receivers, ranges between the transmitter and receiver(s) can be determined, and the position of the transmitter can be found by triangulation.

The accuracy of the location devices and its resistance to multipath effects in indoor environments are determined by the width of the UWB pulse. For example, if the device is to reliably measure different transmitter-receiver ranges when the transmitter is moved from one point to another, the difference in the travel time of the signal from the transmitter to the receiver at the two different positions will be greater than the pulse width. Similarly, a direct path signal and a reflected multipath signal can be separated if the extra time interval required for the signal to travel the reflected path rather than the direct path is greater than the pulse width.

The bandwidth required to generate a pulse with a pulse width T_P is approximately $\left(\frac{1}{T_P}\right)$.

Therefore, for a range resolution or multipath rejection resolution of δR, the bandwidth requirement for the UWB location tracking devices is given by:

$$BW = \frac{c}{(\delta R)}$$

where c is the velocity of light in a vacuum.

For a range resolution of 10 cm, this gives a bandwidth requirement of around 3 GHz.

Annex C: Expected compatibility issues

C.1 Coexistence issues

Possible coexistence problems need to be investigated in ECC-TG3. ECC Report 64 [

], although focussing on UWB for communications equipment, should be considered as a source of information for the purpose of new compatibility studies for UWB sensors.

C.2 Current ITU allocations

There is no current ITU-R allocation corresponding to these devices. The present document assumes operation according to a provision of the Radio Regulations (RR4.4 [8]) that does not require any new allocation (i.e. on a non-protected basis and causing no harmful interference).

Due to the broad range of frequencies covered, an excerpt of the European Common Allocation Table [2] is not reproduced here. Please see [2] for further details.

C.3 Sharing issues

Several issues have to be taken into account, which will decrease the probability of interference with the existing radio services.

The following technical aspects (mitigation factors) need to be taken into account as these will decrease the probability of interference with the existing radio services in a suitable manner:

- low usage activity factor;
- low duty cycle of the devices;
- confined usage area;
- no aggregation effect;
- light licensing for outdoor installations;
- PRF limitation.

There is a considerable interference mitigation effect due to low usage activity factor. The following example explains the assumed effect.

Table C.3.1: Interference mitigation effects

Generic UWB emission limit in 6 GHz to 8,5 GHz range (indoor usage)	-41,3 dBm/MHz
Low duty cycle of 2,5 % Average usage activity factor (8h/24h)	16 dB mitigation 5 dB mitigation
Building attenuation (indoor/outdoor)	10 dB attenuation (as in ECC Report 64 [ ])
Proposed indoor limit (6,4 GHz to 8,5 GHz)	-31,3 dBm/MHz (which leaves a margin of 11 dB with regard to the low duty cycle and usage activity factor mitigation – see [7])
Proposed outdoor limit in 6,4 GHz to 8,5 GHz	-41,3 dBm/MHz (based on indoor/outdoor attenuation)

History

Document history		
V1.1.1	Publication	January 2006
V1.2.1	April 2007	Publication