CEPT Report 84

Report from CEPT to the European Commission in response to the Permanent Mandate on UWB

"Ultra-Wideband technology review in view of a potential update of Commission Implementing Decision (EU) 2019/785"

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0 EXECUTIVE SUMMARY

This Report contains proposed revisions to the technical conditions for UWB applications in the band 6-8.5 GHz. This Report was developed in response to the Permanent Mandate to CEPT to identify the technical conditions relating to the harmonised introduction of radio applications based on Ultra-Wideband (UWB) technology in the European Union.

The recommended framework adds:

- Specific fixed outdoor usage for location and tracking:
  - Maximum mean e.i.r.p. power of -41.3 dBm/MHz, peak power in 50 MHz of 0 dBm;
  - A maximum height of 10 m;
  - For antenna heights above 2.5 m the maximum total radiated power spectral density (TRP_{sd}) is limited to -46.3 dBm/MHz and the antennas must be directive and down tilted;
  - Omnidirectional antennas for data acquisition for authentication / access control (PACS);
  - Limitation of the duty cycle to 5% per second.
- Enhanced specific indoor usage:
  - Maximum mean e.i.r.p. power of -31.3 dBm/MHz, peak power in 50 MHz of 10 dBm;
  - Networked/controlled operation;
  - Only indoor operation of the device;
  - Limitation of the duty cycle to 5% per second.
- Specific vehicular applications within 6-8.5 GHz for vehicle to vehicle and vehicle to infrastructure:
  - Maximum mean e.i.r.p. power of -41.3 dBm/MHz, peak power in 50 MHz of 0 dBm;
  - Limitation of the duty cycle to 1% per second for vehicles;
  - Limitation of the duty cycle to 5% per second for fixed outdoor installations;
  - On-vehicle usage (mounted at the vehicle).

UWB use under these conditions is expected to be exempt from individual licensing and operate on a non-interference non-protected basis. The harmonisation on an EU basis would support EU Directive 2014/53/EU [14] of the European Parliament and of the Council of 16 April 2014 on radio equipment and telecommunications terminal equipment and the mutual recognition of their conformity. Additionally, CEPT has revised an ECC Decision (06)04 [2] to foster wider regional harmonisation of the use of the frequency band 6-8.5 GHz by UWB devices.

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LIST OF ABBREVIATIONS

Abbreviation	Explanation
AF	Activity Factor, as percentage of time that a signal is active
CEPT	European Conference of Postal and Telecommunications Administrations
C-ITS	cooperative intelligent transport system
EC	European Commission
ECC	Electronic Communications Committee
e.i.r.p.	Effective isotropic radiated power
ETSI	European Telecommunications Standards Institute
EU	European Union
EUT	Equipment Under Test
FS	Fixed Service
FSS	Fixed-Satellite Service
ISM	Industrial, Scientific and Medical
ITS	Intelligent Transport System
ITU-R	International Telecommunication Union, Radiocommunication Sector
MCL	Maximum Coupling Loss
NLOS	Non Line of Sight
OoB	Out-of-Band
PACS	Physical Access Control System
RAS	Radio Astronomy Service
RLAN	Radio Local Area Network
TRP_{sd}	Total Radiated power spectral density
UWB	Ultra-Wideband
WAS	Wireless Access System

1 INTRODUCTION

This Report addresses the possible designation of the frequency bands 6-8.5 GHz for the implementation of new UWB applications. This is in accordance with the Permanent Mandate to CEPT to identify the technical conditions relating to the harmonised introduction of radio applications based on Ultra-Wideband (UWB) technology in the European Union (see Annex 2).

The detailed coexistence studies, including technical parameters, which are the basis for this Report are provided in ECC Report 327 [1].

ECC Report 327 studied the coexistence scenarios between UWB applications in the frequency band 6-8.5 GHz and the incumbent usages: Fixed Service (FS), Fixed-Satellite Service (FSS), Radio astronomy (RAS), Earth Exploration-Satellite Service (EESS), EESS (passive), Space Research Service (SRS) and Meteorological Satellite Service (MetSat).

2 UWB USE CASES CONSIDERED

2.1 INTRODUCTION

With the arrival of UWB in mainstream consumer products, standardised solutions for UWB products are becoming more important and prevalent. While the previous IEEE 802.15.4a [5] standard was only used by a number of manufacturers, its successor IEEE 802.15.4z [7] has been adopted up by car manufacturers and mobile phone makers. Two industry consortia, Car Connectivity Consortium and FiRa Consortium, are building standardised solutions on top of this latest IEEE standard. This interest has led to a major increase of chip manufacturers providing standard compliant silicon. The availability of cheaper chipsets for consumer applications means that also other applications areas such as industrial location tracking are switching to standard compliant transmissions.

The channel plan of IEEE 802.15.4a and 4z is identical. It includes 11 channels with 500 MHz bandwidth, as well as 4 channels with roughly 1 GHz bandwidth. However, the latter are not implemented by any chip vendor and are not included in the specifications of the industry consortia. In the 6.0 to 8.5 GHz range, there are 4 channels available, centred at 6.5, 7.0, 7.5 and 8.0 GHz. This channel plan does not make optimal use of the available spectrum in much of the world and therefore the on-going standardisation efforts in Task Group IEEE 802.15.4ab [9] are considering alternative frequency plans such that 5 channels can be included in this frequency range.

In this section, an overview of the planned UWB applications which could drive the development of the updated regulatory framework will be presented. The section is split into the main application areas to be considered in this Report. Based on these applications the main required sharing parameters can be extracted.

To adequately assess the compatibly situation, the future use cases have been analysed and, where necessary, appropriate mitigation factors have been identified. It can be stated that in contrast to the originally assumed use cases in ECC Report 64 [13] the deployment of UWB has mainly focused on location tracking and low data rate communications based on IEEE802.15.4z standards rather than the assumed high and ultra-high data rate systems based on e.g. the ECMA 368 [2] standard or ETSI TS 102 455 [4]. Since the completion of ECC Report 64 in 2005, such high and ultra-high data rate UWB systems did not materialise. Rather, WAS/RLAN systems became the dominant technologies for high and ultra-high data rate transmissions. This leads to a significant reduction of the assumed activity factors.

2.2 FIXED OUTDOOR USAGE FOR LOCATION-TRACKING APPLICATIONS IN THE BAND 6.0-8.5 GHZ

2.2.1 Application overview

In this set of applications, different use cases are covered:

- Parking management applications;
- Outdoor logistics application;
- Home security and access control;
- Positioning systems for vehicular applications for ITS.

These applications can be seen as examples for the use of modern UWB systems for the location and tracking applications.

2.2.2 Parking management

In large cities drivers seeking an available parking space represent a significant pollution source. In addition, time is wasted, and traffic jams may occur. Currently [23] up to 30% of traffic in inner city is created by cars looking for a parking space. This results an increased CO_2 and other emissions, which could be avoided by smart data. To improve logistics and help reducing pollution, intelligent infrastructure systems within the framework of Smart Cities have started to evolve. An important component of such systems is a sensor capable of detecting if a parking lot is occupied or not. The current technology is mainly based on inductive sensing which has some limitations under certain conditions reducing its reliability. By using UWB fixed outdoor systems installed on streetlight, a larger scale monitoring of the parking slots will be possible without having to install a sensor in each of the slots. In addition, identification of a vehicle via UWB allows for identification, which can include permits and payments methods.

2.2.3 Outdoor logistic applications

In outdoor storage area for large equipment like vehicles and machinery the equipment needs to be precisely positioned in order to allow for a smooth delivery of the devices. Due to the large areas a precise localisation system is required. The seamless extension of the indoor location tracking capabilities deploying UWB technologies to the outdoor areas is essential for a broad range of applications in the logistic domain including end-to-end object tracking, fully automated logistic systems and the broad deployment of robotic technologies.

2.2.4 Home security and access control

The primary purpose of a physical access control system (PACS) is to authenticate and authorise a person so that they can pass through a physical portal. However, the architecture of a PACS may vary significantly based on the application (hotel, residential or office access), technology (door types, interface technologies), and manufacturer.

2.2.5 Positioning systems for vehicular applications for ITS

In a future highly automated traffic system including communicating vehicles and other traffic participants (vulnerable road user, see also ETSI STF565 [11] a very high precise positioning information is required for each of the participants (vehicles, pedestrians, animals, etc.). The participants can evaluate their position by different means like GPS, optical sensors or UWB ranging operations. This position information together with additional characteristics of the traffic participants are distributed using a cooperative intelligent transport system (C-ITS). The receiving party can then build a detailed picture of its surroundings including all traffic participants.

A very high precision is especially required at dense traffic crossing situations, where precisions down to 10 cm are required. In these urban scenarios the coverage with GNSS can be very limited and thus an additional system for a high precision positioning will be required.

These scenarios are supported by fixed infrastructure integrated into the overall ITS system.

2.3 GENERAL VEHICULAR APPLICATIONS IN THE BAND 6.0-8.5 GHZ

In the domain of intelligent transport systems (ITS), very high precision positioning is required in specific traffic situations like high density road crossings involving different traffic participants from cars to trucks to pedestrians (vulnerable road users, VRU). It can be assumed that an accuracy of 25 cm under dynamic behaviour is required to identify the used lane or the position of a pedestrian at the road-side.

2.4 HIGHER POWER INDOOR ONLY APPLICATIONS USAGE IN THE BAND 6.0-8.5 GHZ

UWB technology deployment is normally limited to the extremely low power spectral density of only -41.3 dBm/MHz. This limitation allows precise ranging at shorter distances, which would be sufficient for normal sized rooms, like small office spaces, meeting rooms and apartments.

There are huge exhibition and concert halls where the dimension of the geo-space requires increased link budget in order to cover the hall dimensions in a seamless way. Seamless and reliable coverage is an important feature required for reliable contact tracing in order to allow public authorities to set up sufficiently comprehensive tracing actions in case of an infection.

There are also potential usages in residential or industrial environments where higher power levels would allow for larger coverage ranges. Very often finding suitable locations for UWB devices is difficult, increased ranges due to higher power would help the end user to setup corresponding systems.

Furthermore, very precise tracking and ranging of dynamic situations at shorter distances would also benefit significantly from increased power levels.

3 REVIEW OF COEXISTENCE ISSUES

3.1 OVERVIEW

The UWB applications that have been investigated in ECC Report 327 [1] are used for radiodetermination and location tracking, tracing and data acquisition. They operate in the field of logistics and traffic management, home security applications and access control, indoor positioning applications and vehicular applications.

Study results presented in ECC Report 327 evaluate whether compatibility with incumbent system in the band 6.0 GHz to 8.5 GHz could be achieved, when UWB devices are operating with -41.3 dBm/MHz either as fixed installations or in road vehicles and whether a limited number of indoor devices can operate with an increase Tx power of up to -31.3 dBm/MHz.

To adequately assess the compatibly situation, the future use cases have been analysed and, where necessary, appropriate mitigation factors have been identified. It can be stated that in contrast to the originally assumed use cases in ECC Report 64 [13] the deployment of UWB has mainly focused on location tracking and low data rate communications based on IEEE802.15.4z [7] standards rather than the assumed high and ultra-high data rate systems based on e.g. the ECMA 368 [3] standard or ETSI TS 102 455 [4]. Since the completion of ECC Report 64 in 2005, such high and ultra-high data rate UWB systems did not materialise. Rather, WAS/RLAN systems became the dominant technologies for high and ultra-high data rate transmissions. This leads to a significant reduction of the assumed activity factors.

Furthermore, today's technology can provide several operational channels also in the band 6-8.5 GHz which can be taken into account in the band apportionment and thus reducing the density of devices in a potential victim band further.

These effects have mainly been taken into account in the aggregation investigations.

In ECC Report 327, the peak power effect of UWB devices have been investigated for the first time in more detail, especially in the fixed service investigations.

The different types of applications and their parameters studied in this Report are summarised in Table 1.

Table 1: Summary of the applications and their parameters

Application	Assumed Density	Activity factor	Transmit Power (e.i.r.p.)
Fixed outdoor application			
Parking management application	Urban: max. 40 devices/km or 400 devices/km^2 Suburban: 100 device/ km^2 Rural: 10 devices/km^2	AF: 0.05%	-41.3 dBm/MHz mean e.i.r.p. power density in 1 ms 0 dBm/50 MHz (max), peak e.i.r.p. power
Outdoor logistics	Outdoor logistics: max. 1000/km^2 Urban: 50/km^2 Suburban: 100/km^2 Rural: 10/km^2	AF: 0.3%	-41.3 dBm/MHz mean e.i.r.p. power density in 1 ms 0 dBm/50 MHz (max), peak e.i.r.p. power
Physical access control system (PACS)	Urban: 200/km^2 Suburban: 50/km^2 Rural: 10/km^2	AF: 0.006%	-41.3 dBm/MHz mean e.i.r.p. power density in 1 ms 0 dBm/50 MHz (max), peak e.i.r.p. power

Application	Assumed Density	Activity factor	Transmit Power (e.i.r.p.)
Vehicular applications fixed outdoor installations	Max. 40 devices per km of road; 400 devices per km², 10 km road length in 1 km² Urban: 400/km² Suburban: 50/km² Rural: 10/km²	Urban AF: 5% Suburban: 2% Rural: 0.5%	-41.3 dBm/MHz mean e.i.r.p. power density in 1 ms 0 dBm/50 MHz (max), peak e.i.r.p. power
General vehicular outdoor applications for ITS			
Vehicular applications, vehicle installations	6000 per km² max. (10 3-lane roads two directions dense traffic), typical 1000 per km² Urban: 1000/km² Suburban: 100/km² Rural: 25/km²	AF: 1% max AF typical: 0.4% AF: 0.04% for V2V	-41.3 dBm/MHz mean e.i.r.p. power density in 1 ms 0 dBm/50 MHz (max), peak e.i.r.p. power
High power indoor devices			
Indoor systems with higher power	Urban: 1000 to 2500 devices/km² Suburban: 100 to 250/km² Rural: 25/km²	AF: 1%	-31.3 dBm/MHz mean e.i.r.p. power density in 1 ms 10 dBm/50 MHz (max), peak e.i.r.p. power

Due to the mentioned additional mitigation factors the overall interference potential of the applications investigated in this Report is lower than the interference potential of the already regulated generic UWB devices based on ECC Decision (06)04 [2].

ECC Report 327 [1] outlines that the three following factors are key in assessing the compatibility between UWB devices with relaxed conditions and incumbents systems across the band 6-8.5 GHz:

- Reduced densities of UWB devices compared to the ones considered in ECC Report 64 [13];
- Consideration of use cases associated with low data rate and low activity factors as the one considered in ECC Decision (06)04 [2];
- Ability for UWB devices to spread, on an aggregate basis, across a number of possible operational channels.

For each considered application, the assumed device density taken into account in the studies, is described in Table 1. It was noted that if the deployment densities assumed in this report are exceeded, further studies on additional mitigation techniques may be required in order to ensure coexistence with outdoor stations of radiocommunication services.

For fixed outdoor installations, coexistence would be possible based on the following assumptions:

- Maximum mean e.i.r.p. power of -41.3 dBm/MHz, peak power in 50 MHz of 0 dBm;
- Maximum height of 10 m;
- Directive antennas are down tilted to provide additional attenuation of 5 dB for parking management, outdoor logistics and fixed vehicular applications;
- Omnidirectional antennas for data acquisition for authentication / access control (PACS);
- Duty Cycle < 5% per second.

For indoor installations (both fixed installations and portable devices), coexistence would be possible based on the following assumptions:

- Maximum mean e.i.r.p. power of -31.3 dBm/MHz, peak power in 50 MHz of 10 dBm;
- Duty Cycle < 5% per second;

- Networked/controlled operation.

For vehicular applications coexistence would be possible based on the following assumptions:

- Maximum mean e.i.r.p. power of -41.3 dBm/MHz, peak power in 50 MHz of 0 dBm;
- Maximum height of 4 m;
- Omnidirectional antennas;
- Duty Cycle < 1% per second.

3.2 FIXED SERVICE (FS)

MCL calculations show a maximum separation distance of 11226 m for the outdoor line of sight scenario. Taking into account vertical geometries this distance can be reduced to 10965 m.

For outdoor NLOS scenarios the maximum separation distance is 1484 m. Taking into account vertical geometries this distance can be reduced to 250 m. That behaviour can be explained by using a suburban/urban clutter model, adding minimum 16.7 dB attenuation for distances greater than 250 m.

Outside of the FS main lobe, the minimum separation distance is about 50 m without applying any clutter.

Additional results leading to smaller distances than shown above, covering also indoor scenarios, peak power scenarios and a FS antenna scenario with lower peak gain are included in ECC Report 327, annex 2.

For the indoor high-power UWB applications, a geometrical minimum required separation distance for aggregated propagation effects study was performed with indoor high-power UWB using the geometrical approach where the effective FS antenna gain is calculated based on the relative position of the UWB device compared to the FS receiver. Recommendation ITU-R P.452-16 [15] was used to model propagation losses, Recommendation ITU-R P.2109 [16] to model building entry losses, and Recommendation ITU-R P.2108 [17] for clutter losses. All the propagation losses were aggregated into one statistical loss, which was used to determine the minimum separation distance at different percentiles p. Four different scenarios were considered consisting of two types of buildings, traditional and thermally efficient, and two types of propagation conditions. The first considers propagation losses and building entry losses, and another one considers clutters losses besides propagation losses and building entry losses. The overall CDF of the losses was computed and evaluated for p = 1%, p = 10%, and p = 50%, where p represents the percentile of the overall losses. The results assuming no clutter and traditional buildings span from 0.25 km to 25.5 km, whereas for thermally efficient buildings they span from 0 km to 19.75 km. The results assuming clutter and traditional buildings span from 0 km to 0.26 km, whereas for thermally efficient buildings they span from 0 km to 0.25 km.

Two Monte Carlo studies were carried out. Results from a large number of Monte Carlo events show that the percentage of events for which the short-term threshold (I/N = 19 dB) is not exceeded for more than $4.5 \cdot 10^{-5}$% (which was used as a proxy for short-term protection criterion). The long-term threshold (I/N = -20 dB) is not exceeded for more than 1.7%, which is below 20%. Although there are no clear guidelines given in the regulatory literature regarding the allowed exceedance time for the peak power criterion, considering that the other 2 examined criteria are met, it can be assumed that this criterion is also met.

A simultaneous assessment of RLAN and UWB systems has not been done. Given that the significantly lower interference levels of UWB compared to RLAN, a significant increase of the overall impact is not expected.

It is noted that the simulations carried out used space- and time-based distributions for calculating a percentage of interference. Therefore, results are in terms of time-space percentage and not in terms of time percentage only. This needs to be taken into account in the interpretation of results.

3.3 FIXED SATELLITE SERVICE (FSS)

MCL calculations show a maximum separation distance of 25386 m from the FSS receiver for the LOS scenario. Taking into account vertical geometries and the corresponding elevation angles this distance can be reduced to 156 m, even without taking clutter into account.

For NLOS scenarios the maximum separation distance is 1428 m from the FSS receiver. Taking into account vertical geometries this distance can be reduced to 156 m.

Outside of the FSS main beam, the minimum separation distance is about 34 m without applying any clutter.

The MCL calculations included in this Report are based on the assumption of a FSS systems operating in dense urban environments. The compatibility studies take into account the FSS antenna patterns for an elevation of 10° and the relative heights of 20 m between the FSS antenna and the UWB devices. Different dish sizes have been considered. Only the outdoor UWB deployment has been taken into account.

For all dish sizes above 3 m, the minimum separation distance in main beam direction of the FSS is 30 m in the considered urban environment. For smaller antenna dish sizes this distance increases to 190 m for a dish size of 1.8 m and 250 m for a dish size of 1.2 m in the considered urban environment.

MCL calculations for FSS systems operating in rural environment have not been considered.

Aggregate interference studies using Monte-Carlo methodology show that the long term and short-term interference criterion is met in all scenarios for mean and peak e.i.r.p. based on a sensitivity analysis on the difference of FSS deployment in rural and urban environment with specific FSS height and dish antenna diameter associated to their deployment as well as on the size of the exclusion zone and elevation angle.

3.4 RADIO ASTRONOMY SERVICE (RAS)

For the investigation of any potential compatibility issues between UWB and RAS, an extensive analysis has been performed taking into account single entry scenarios and aggregation scenarios with the focus on outdoor deployments.

For the compatibility with the RAS, the local Tx-side clutter zone type and the Tx antenna heights play a key role. As long as (all) antennas of an installation are within the clutter, no interference at the RAS observatory is expected once the UWB device is beyond about 1 km distance. However, some of the proposed usage scenarios involve relatively high antennas, which can at least in part exceed the local clutter heights and will utilise a relatively high number density of devices and activity factors. In these cases, coordination with the RAS on a national level will be necessary in a given area around the RAS stations. Based on generic (flat-terrain) analyses, the coordination zone could be of the order of 10 km radius around a site, but local terrain and clutter properties would permit to install devices in a fair number of positions within such a coordination zone without putting RAS operations in danger.

The results for the vehicular-to-vehicular case show that for UWB devices attached to vehicles compatibility with RAS is given for most sites that were studied here. This is owing to the low traffic density and the clutter conditions around the stations. In fact, RAS stations are in most cases purposefully located in remote areas for exactly this reason. A minimal separation distance of 0.5 km to 1 km should suffice for adequate protection. Unfortunately, for the Jodrell Bank station the situation is somewhat worse, as there is more traffic and higher population density in the area than can be found at the other RAS sites. Here, an exclusion zone of up to 4-5 km may be needed. Taking into account that the considered activity factor of 0.4% in the V2V investigation is significantly higher than the assumed activity factor for this kind of application (AF ≤ 0.04%) this exclusion or control zone could be changed when the real AFs are taken into account.

3.5. SPACE SCIENCE SERVICES

3.5.1 EESS (SPACE-TO-EARTH), SRS (SPACE-TO-EARTH) AND METEOROLOGICAL-SATELLITE SERVICE (SPACE-TO-EARTH)

The single-entry studies included in ECC Report 327 [1] show mitigation distances between 300 m and 3600 m for a UWB device operating with 100% duty cycle and assuming a LoS path towards the installations.

In addition, aggregated interference investigations have been performed, taking into account the UWB applications deployments assumed in this Report. The calculations of aggregated interference into SRS/EESS/MetSat earth stations, assuming flat terrain around the Earth stations, without consideration of clutter, show that the SRS/EESS/MetSat protection criteria are met with the application of the following minimal separation distances between the concerned earth stations and any UWB application:

- For UWB fixed outdoor installation:
  - 2 km around SRS earth station for near Earth SRS missions and 1.5 km for deep space SRS missions;
  - 100 m around EESS and MetSat earth station.
- For UWB vehicle installation:
  - 10 km around SRS earth station for near Earth SRS missions and 8 km for deep space SRS missions;
  - 700 m around EESS earth station;
  - 400 m around MetSat earth station.

- For UWB fixed outdoor installation:
  - 2 km around SRS earth station for near Earth SRS missions and 1.5 km for deep space SRS missions;
  - 100 m around EESS and MetSat earth station.
- For UWB vehicle installation:
  - 10 km around SRS earth station for near Earth SRS missions and 8 km for deep space SRS missions;
  - 700 m around EESS earth station;
  - 400 m around MetSat earth station.

Additional site-specific simulations have been performed for UWB vehicles installations to assess the impact of considering terrain and clutter on the required separations distances. These simulations show that the consideration of terrain and clutter, as appropriate, leads to significantly lower separation distances:

- 5 km around the SRS earth station located in Cebreros (Spain), when considering terrain without additional clutter;
- 300 m around the SRS earth station located in Cebreros (Spain), when considering terrain with additional clutter (17 dB) around the UWB stations;
- 500 m around the EESS station located in Weilheim (Germany) when considering terrain without additional clutter.

In the case of UWB indoor positioning applications, it is anticipated that the indoor to outdoor attenuation together with additional factors (such as body loss and clutter loss and the separation distances between indoor UWB deployments and SRS/EESS/MetSat earth stations) would provide enough mitigation to avoid interference from the specific UWB indoor deployments considered in this Report to SRS/EESS/MetSat earth stations. This scenario was therefore not addressed in these aggregated interference assessments.

3.5.2 EESS (EARTH-TO-SPACE), SRS (EARTH-TO-SPACE) AND METEOROLOGICAL-SATELLITE SERVICE (EARTH-TO-SPACE)

No impact from UWB systems is expected into EESS, SRS and MetSat spacecraft receivers in the context of ECC Report 327 [1].

3.5.3 EESS(PASSIVE) USED UNDER RR NO. 5.458 (6425-7250 MHZ)

The spectrum sharing studies with EESS passive sensors in the band 6425 MHz to 7250 MHz show negative interference margin for most of the proposed applications and corresponding interference scenarios considered in this Report. This applies to both the single-entry and the aggregate interference calculations.

However, the degradation of the radio environment experienced by EESS passive sensors caused by the applications presented in this Report is expected to be generally smaller than that caused by the operation of generic UWB devices based on the existing regulation in ECC Decision (06)04 [2] and the related assumed activity factors and device densities in ECC Report 64 [13].

4 RECOMMENDED FRAMEWORK

4.1 INTRODUCTION

Proposed harmonised technical conditions are presented in Annex 1.

The recommended revision of the framework for UWB applications in the frequency band 6-8.5 GHz is shown in shown in the following clauses.

4.2 FIXED OUTDOOR USAGE

- Maximum mean e.i.r.p. power of -41.3 dBm/MHz, peak power in 50 MHz of 0 dBm;
- Maximum height of 10 m;
- For antenna heights above 2.5 m the maximum total radiated power density (TRP_{sd}) is limited to -46.3 dBm/MHz;
- Omnidirectional antennas for data acquisition for authentication / access control (PACS);
- Limitation of the duty cycle to 5% per second.

Under these conditions the restriction of non-fixed outdoor (Decision 2007/131/EC, Article 3 [22]) could be removed for UWB systems operating in the band 6 GHz to 8.5 GHz.

The antenna gain of greater than 5 dBi leads to lower radiated emissions in other directions than the main beam and reduces the overall interference impact. The minimum antenna gain of 5 dBi should be expressed as a limit of the total radiated power spectral density TRP_{sd} equal or smaller than -46.3 dBm/MHz.

4.3 SPECIFIC VEHICULAR APPLICATIONS WITHIN 6-8.5 GHZ FOR VEHICLE TO VEHICLE AND VEHICLE TO INFRASTRUCTURE

- Maximum mean e.i.r.p. power of -41.3 dBm/MHz, peak power in 50 MHz of 0 dBm;
- Limitation of the duty cycle to 1% per second for vehicles;
- Limitation of the duty cycle to 5% per second for fixed outdoor installations;
- On-vehicle usage (mounted at the vehicle).

These harmonised technical conditions would have to be applied in the corresponding ETSI harmonised standard to be developed for adoption under Directive 2014/53/EU [14].

4.4 SPECIFIC APPLICATIONS INVOLVING ENHANCED INDOOR DEVICES

- Maximum mean e.i.r.p. power of -31.3 dBm/MHz, peak power in 50 MHz of 10 dBm;
- Indoor operation only;
- Limitation of the duty cycle of 5% per second;
- Portable device controlled by an indoor infrastructure.

ANNEX 1: PROPOSED HARMONISED TECHNICAL CONDITIONS FOR UWB BELOW 10.6 GHZ

A1.1 GENERIC ULTRA-WIDEBAND (UWB) USAGE

The technical requirements below are not applicable to:

a) devices and infrastructure used at a fixed outdoor location or connected to a fixed outdoor antenna;
b) devices installed in flying models, aircraft and other aviation;
c) devices installed in road and rail vehicles.

Table 1: Maximum e.i.r.p. limits

	Technical conditions	
Frequency band	**Maximum mean power spectral density (e.i.r.p.)**	**Maximum peak power (e.i.r.p.) (defined in 50 MHz)**
f ≤ 1.6 GHz	-90 dBm/MHz	-50 dBm
1.6 < f ≤ 2.7 GHz	-85 dBm/MHz	-45 dBm
2.7 < f ≤ 3.1 GHz	-70 dBm/MHz	-36 dBm
3.1 < f ≤ 3.4 GHz	-70 dBm/MHz or -41.3 dBm/MHz using LDC (note 1) or DAA (note 2)	-36 dBm or 0 dBm
3.4 < f ≤ 3.8 GHz	-80 dBm/MHz or -41.3 dBm/MHz using LDC (note 1) or DAA (note 2)	-40 dBm or 0 dBm
3.8 < f ≤ 4.8 GHz	-70 dBm/MHz or -41.3 dBm/MHz using LDC (note 1) or DAA (note 2)	-30 dBm or 0 dBm
4.8 < f ≤ 6 GHz	-70 dBm/MHz	-30 dBm
6 < f ≤ 8.5 GHz	-41.3 dBm/MHz	0 dBm
8.5 < f ≤ 9 GHz	-65 dBm/MHz or -41.3 dBm/MHz using DAA (note 2)	-25 dBm or 0 dBm
9 < f ≤ 10.6 GHz	-65 dBm/MHz	-25 dBm
f > 10.6 GHz	-85 dBm/MHz	-45 dBm

Note 1: Within the 3.1 GHz to 4.8 GHz band. The Low Duty Cycle (‘LDC’) mitigation technique and its limits are defined in ETSI EN 302 065-1 V2.1.1, clauses 4.5.3.1, 4.5.3.2 and 4.5.3.3 [19]. Alternative mitigation techniques may be used if they ensure at least an equivalent performance and level of spectrum protection in order to comply with the corresponding essential requirements of Directive 2014/53/EU of the European Parliament and of the Council of 16 April 2014 on the harmonisation of the laws of the Member States relating to the making available on the market of radio equipment and repealing Directive 1999/5/EC [14] (OJ L 153, 22.5.2014, p. 62) and respect the technical requirements of this Decision.

Note 2: Within the 3.1 GHz to 4.8 GHz and 8.5 GHz to 9 GHz bands. The Detect and Avoid (‘DAA’) mitigation technique and its limits are defined in ETSI EN 302 065-1 V2.1.1, clauses 4.5.1.1, 4.5.1.2 and 4.5.1.3 [19]. Alternative mitigation techniques may be used if they ensure at least an equivalent performance and level of spectrum protection in order to comply with the corresponding essential requirements of Directive 2014/53/EU and respect the technical requirements of this Decision.

A1.2 LOCATION TRACKING SYSTEMS TYPE 1 (LT1)

Table 2: Maximum e.i.r.p. limits

	Technical conditions	
Frequency band	Maximum mean power spectral density (e.i.r.p.)	Maximum peak power (e.i.r.p.) (defined in 50 MHz)
f ≤ 1.6 GHz	-90 dBm/MHz	-50 dBm
1.6 < f ≤ 2.7 GHz	-85 dBm/MHz	-45 dBm
2.7 < f ≤ 3.4 GHz	-70 dBm/MHz	-36 dBm
3.4 < f ≤ 3.8 GHz	-80 dBm/MHz	-40 dBm
3.8 < f ≤ 6.0 GHz	-70 dBm/MHz	-30 dBm
6 < f ≤ 8.5 GHz	-41.3 dBm/MHz	0 dBm
8.5 < f ≤ 9 GHz	-65 dBm/MHz or -41.3 dBm/MHz using DAA (note 1)	-25 dBm or 0 dBm
9 < f ≤ 10.6 GHz	-65 dBm/MHz	-25 dBm
f > 10.6 GHz	-85 dBm/MHz	-45 dBm
Note 1: The DAA mitigation technique and its limits are defined in ETSI EN 302 065-2 V2.1.1, clauses 4.5.1.1, 4.5.1.2 and 4.5.1.3 [20]. Alternative mitigation techniques may be used if they ensure at least an equivalent performance and level of spectrum protection in order to comply with the corresponding essential requirements of Directive 2014/53/EU and respect the technical requirements of this Decision.		

A1.3 UWB DEVICES INSTALLED IN MOTOR AND RAILWAY VEHICLES

A1.3.1 General case

Table 3: Maximum e.i.r.p. limits

	Technical conditions	
Frequency band	Maximum mean power spectral density (e.i.r.p.)	Maximum peak power (e.i.r.p.) (defined in 50 MHz)
f ≤ 1.6 GHz	-90 dBm/MHz	-50 dBm
1.6 < f ≤ 2.7 GHz	-85 dBm/MHz	-45 dBm
2.7 < f ≤ 3.1 GHz	-70 dBm/MHz	-36 dBm
3.1 < f ≤ 3.4 GHz	-70 dBm/MHz or -41.3 dBm/MHz using LDC (note 1) + e.l. (note 4) or	-36 dBm or ≤ 0 dBm or ≤ 0 dBm

	Technical conditions	
	-41.3 dBm/MHz using TPC (note 3), DAA (note 2) and e.l. (note 4)	
3.4 < f ≤ 3.8 GHz	-80 dBm/MHz or -41.3 dBm/MHz using LDC (note 1) and e.l. (note 4) or -41.3 dBm/MHz using TPC (note 3), DAA (note 2) and e.l. (note 4)	-40 dBm or ≤ 0 dBm or ≤ 0 dBm
3.8 < f ≤ 4.8 GHz	-70 dBm/MHz or -41.3 dBm/MHz using LDC (note 1) and e.l. (note 4) or -41.3 dBm/MHz using TPC (note 3), DAA (note 2) and e.l. (note 4)	-30 dBm or ≤ 0 dBm or ≤ 0 dBm
4.8 < f ≤ 6 GHz	-70 dBm/MHz	-30 dBm
6 < f ≤ 8.5 GHz	-53,3 dBm/MHz or -41.3 dBm/MHz using LDC (note 1) and e.l. (note 4) or -41.3 dBm/MHz using TPC (note 3) and e.l. (note 4)	-13.3 dBm or ≤ 0 dBm or ≤ 0 dBm
8.5 < f ≤ 9 GHz	-65 dBm/MHz or -41.3 dBm/MHz using TPC (note 3), DAA (note 2) and e.l. (note 4)	-25 dBm or ≤ 0 dBm
9< f ≤ 10.6 GHz	-65 dBm/MHz	-25 dBm
f > 10.6 GHz	-85 dBm/MHz	-45 dBm

Note 1: The LDC mitigation technique and its limits are defined in ETSI EN 302 065-3 V2.1.1 clauses 4.5.3.1, 4.5.3.2 and 4.5.3.3 [21]. Alternative mitigation techniques may be used if they ensure at least an equivalent performance and level of spectrum protection in order to comply with the corresponding essential requirements of Directive 2014/53/EU and respect the technical requirements of this Decision.

Note 2: The DAA mitigation technique and its limits are defined in ETSI EN 302 065-3 V2.1.1, clauses 4.5.1.1, 4.5.1.2 and 4.5.1.3 [21]. Alternative mitigation techniques may be used if they ensure at least an equivalent performance and level of spectrum protection in order to comply with the corresponding essential requirements of Directive 2014/53/EU and respect the technical requirements of this Decision.

Note 3: The Transmit Power Control ('TPC') mitigation technique and its limits are defined in ETSI EN 302 065-3 V2.1.1, clauses 4.7.1.1, 4.7.1.2 and 4.7.1.3 [21]. Alternative mitigation techniques may be used if they ensure at least an equivalent performance and level of spectrum protection in order to comply with the corresponding essential requirements of Directive 2014/53/EU and respect the technical requirements of this Decision.

Note 4: The exterior limit (e.l.) ≤ – 53.3 dBm/MHz is required. The exterior limit is defined in ETSI EN 302 065-3 V2.1.1, clauses 4.3.4.1, 4.3.4.2 and 4.3.4.3 [21]. Alternative mitigation techniques may be used if they ensure at least an equivalent performance and level of spectrum protection in order to comply with the corresponding essential requirements of Directive 2014/53/EU and respect the technical requirements of this Decision.

A1.3.2 Specific vehicular access systems using trigger-before-transmit

Technical requirements to be used within the bands 3.8-4.2 GHz and 6-8.5 GHz for vehicular access systems using trigger-before-transmit are defined in the following table.

Table 4: Maximum e.i.r.p. limits

	Technical conditions	
Frequency band	Maximum mean power spectral density (e.i.r.p.)	Maximum peak power (e.i.r.p.) (defined in 50 MHz)
3.8 < f ≤ 4.2 GHz	-41.3 dBm/MHz with trigger-before-transmit operation and LDC ≤ 0,5 % (in 1h)	0 dBm
6 < f ≤ 8.5 GHz	-41.3 dBm/MHz with trigger-before-transmit operation and LDC ≤ 0,5 % (in 1h) or TPC	0 dBm

'Trigger-before-transmit' mitigation is defined as a UWB transmission that is only initiated when necessary, specifically where the system indicates that UWB devices are nearby. The communication is either triggered by a user or by the vehicle. The subsequent communication can be considered as 'triggered communication'. The existing LDC mitigation applies (or alternatively TPC in the 6 GHz to 8.5 GHz range). An exterior limit requirement must not be applied when using the trigger-before-transmit mitigation technique for vehicular access systems.

Trigger-before-transmit mitigation techniques that provide an appropriate level of performance in order to comply with the essential requirements of Directive 2014/53/EU shall be used for vehicular access systems. If relevant techniques are described in harmonised standards or parts thereof the references of which have been published in the Official Journal of the European Union under Directive 2014/53/EU, performance at least equivalent to these techniques shall be ensured. These techniques shall respect the technical requirements of this Decision.

A1.3.3 Other vehicular applications, including applications involving infrastructure to vehicle and vehicle to vehicle communications in 6-8.5 GHz

The technical requirements of Table 6 are applicable to vehicular applications operating in 6-8.5 GHz, including applications involving infrastructure to vehicle and vehicle to vehicle communications. The technical requirements applicable to emissions below 6 GHz and above 8.5 GHz are to be used from Table 4

Table 5: Maximum e.i.r.p. limits

Frequency range	Maximum mean e.i.r.p. spectral density	Maximum peak e.i.r.p. (defined in 50 MHz)
6 < f ≤ 8.5 GHz (Notes 1 and 2)	-41.3 dBm/MHz	0 dBm
Note 1: within the band 6-8.5 GHz, the following additional requirements apply to fixed outdoor installations supporting communication with UWB devices installed in road and rail vehicles: Antennas are directive, down tilted and installed at a maximum height of 10 m; The duty cycle is limited to maximum 5% per second. Note 2: within the band 6-8.5 GHz, the following additional requirements apply to UWB devices installed in road and rail vehicles: Antennas are installed at a maximum height of 4 m; The duty cycle is limited to maximum 1% per second.		

A1.4 SPECIFIC RADIODETERMINATION, LOCATION TRACKING, TRACING AND DATA ACQUISITION APPLICATIONS IN 6-8.5 GHZ

A1.4.1 Specific applications involving fixed outdoor installations

The technical requirements of Table 7 are applicable to devices and infrastructure used at a fixed outdoor location or connected to a fixed outdoor antenna and supporting radiodetermination, location tracking, tracing or data acquisition applications operating in 6-8.5 GHz.

Table 6: Maximum e.i.r.p. limits

Frequency range	Maximum mean e.i.r.p. spectral density	Maximum peak e.i.r.p. (defined in 50 MHz)
f ≤ 1.6 GHz	-90 dBm/MHz	-50 dBm
1.6 < f ≤ 2.7 GHz	-85 dBm/MHz	-45 dBm
2.7 < f ≤ 3.1 GHz	-70 dBm/MHz	-36 dBm
3.1 < f ≤ 3.4 GHz	-70 dBm/MHz	-36 dBm
3.4 < f ≤ 3.8 GHz	-80 dBm/MHz	-40 dBm
3.8 < f ≤ 4.2 GHz	-70 dBm/MHz	-30 dBm
4.2 < f ≤ 4.8 GHz	-70 dBm/MHz	-30 dBm
4.8 < f ≤ 6 GHz	-70 dBm/MHz	-30 dBm
6 < f ≤ 8.5 GHz (Notes 1, 2 and 3)	-41.3 dBm/MHz	0 dBm
8.5 < f ≤ 10.6 GHz	-65 dBm/MHz	-25 dBm
f > 10.6 GHz	-85 dBm/MHz	-45 dBm

Note 1: Within the band 6-8.5 GHz, the duty cycle is limited to maximum 5% per second and antennas are installed at a maximum height of 10 m.

Note 2: For antenna heights above 2.5 m the maximum total radiated power spectral density (TRP_{sd}) is limited to -46.3 dBm/MHz and the antennas must be directive and down tilted.

Note 3: Antennas for data acquisition for authentication/access control (PACS) are excluded from the antenna directivity requirements given under Note 2.

A1.4.2 Specific applications involving enhanced indoor devices

The technical requirements of Table 8 are applicable to enhanced power devices operating indoor and supporting radiodetermination, location tracking, tracing or data acquisition applications operating in 6-8.5 GHz. The technical requirements applicable to emissions below 6 GHz and above 8.5 GHz are defined in Table 2.

Table 7:Maximum e.i.r.p. limits

Frequency range	Maximum mean e.i.r.p. spectral density	Maximum peak e.i.r.p. (defined in 50 MHz)
6 < f ≤ 8.5 GHz (Note 1)	-31.3 dBm/MHz	10 dBm

Note 1: within the band 6-8.5 GHz, the duty cycle is limited to maximum 5% per second. Portable devices can operate with a maximum mean e.i.r.p. spectral density higher than -41.3 dBm/MHz and a maximum peak e.i.r.p. higher than 0 dBm defined in 50 MHz only within an identifiable network and subject to control by an indoor infrastructure.

A1.5 UWB ONBOARD AIRCRAFT

No change

A1.6 MATERIAL SENSING DEVICES USING UWB TECHNOLOGY

ECC Decision (07)01 [18] was editorial corrected in 2022. To avoid conflicts with other decisions and recommendations it was decided to be more precise in the naming of the mitigation “Total radiated power”.

Based on that the Total Radiated power requirement is based on the measured mean power spectral density (e.i.r.p) around the EUT, the more precise wording is Total Radiated Power spectral density (TRP_{sd}).

There is no need change any requirements, only the wording needs to be revised for the revised EC/DEC on UWB. This wording is still considered for the EUT covered by the proposed changes in the upper clause.

Therefore, it is proposed to change in clause 5.2, Note (2) below the table and clause 5.3, Note (2) below the table from

“*(2) To protect the radio services, non-fixed installations must fulfil the following requirement for total radiated power:*”

To

“*(2) To protect the radio services, non-fixed installations must fulfil the following requirement for total radiated power spectral density:*”

A1.7 RELEVANT DEFINITIONS

Replace Article 2, paragraph (i)

> *(i) ‘total power spectral density’ means the average of the mean power spectral density values measured over a sphere around the measurement scenario with a resolution of at least 15 degrees;*

With

> *(i) ‘total radiated power spectral density’ (TRP_{sd}) means the average of the mean power radiated spectral density values measured over a sphere around the UWB device (generic or vehicular use) or around the use-case related scenario(as indirect emissions for UWB devices determining materials devices). The measurement of the mean power spectral density (E.i.r.p) shall be performed with a resolution of 15 degrees;*

A1.8 FIXED OUTDOOR IN ARTICLE 3

In article 3, fixed outdoor is generally excluded from the regulation. This is in contradiction to the new regulation. For the generic UWB usage this is still valid and explicitly set out in the annex under A1.1.

Replace Article 3:

“Within six months after this Decision takes effect, Member States shall designate and make available the radio spectrum, on a non-interference and non-protected basis, for equipment using ultra-wideband technology provided that such equipment meets the conditions set out in the Annex and it is used indoors or, if it is used outdoors, it is not attached to a fixed installation, a fixed infrastructure or a fixed outdoor

antenna. Equipment using ultra-wideband technology which meets the conditions set out in the Annex shall also be allowed in motor and railway vehicles."

with

"Within six months after this Decision takes effect, Member States shall designate and make available the radio spectrum, on a non-interference and non-protected basis, for equipment using ultra-wideband technology provided that such equipment meets the conditions set out in the Annex and it is used indoors or, if it is used outdoors, it is not attached to a fixed installation, a fixed infrastructure or a fixed outdoor antenna. Equipment using ultra-wideband technology which meets the conditions set out in the Annex shall also be allowed in motor and railway vehicles or attached to a fixed installation, a fixed infrastructure or a fixed outdoor antenna if explicitly permitted in the Annex."

ANNEX 2: CEPT MANDATE

Ref. Ares(2019)7872964 - 20/12/2019

EUROPEAN COMMISSION
Directorate-General for Communications Networks, Content and Technology

Electronic Communications Networks and Services
Radio Spectrum Policy

Brussels, 11 December 2019
DG CONNECT/B4

RSCOM17-04rev4

FINAL

RADIO SPECTRUM COMMITTEE

Working Document

Subject: **Permanent Mandate to CEPT to identify the technical conditions relating to the harmonised introduction of radio applications based on Ultra-Wideband (UWB) technology in the European Union**

Opinion of the RSC pursuant to Advisory Procedure under Article 4 of Regulation 182/2011/EU and Article 4.2 of Radio Spectrum Decision 676/2002/EC

PERMANENT MANDATE
TO CEPT

TO IDENTIFY THE TECHNICAL CONDITIONS RELATING TO THE HARMONISED INTRODUCTION OF RADIO APPLICATIONS BASED ON ULTRA-WIDEBAND (UWB) TECHNOLOGY IN THE EUROPEAN UNION

Purpose

The underlying objective of this Mandate is to provide updated technical parameters to amend Commission Implementing Decision (EU) 2019/785 on the harmonisation of radio spectrum for equipment using ultra-wideband technology in the Union and repealing Decision 2007/131/EC in order to:

- expand its scope to different operating environments and specific ultra-wideband applications according to market demand;
- ensure less restrictive operation and specific techniques to ensure appropriate mitigation of potential harmful interference to radiocommunication services and radio applications.

Pursuant to this permanent Mandate, CEPT shall provide the Commission, when needed, with an assessment on the needs for updating the technical annex of the Commission Implementing Decision .

If the assessment performed by CEPT points to a need to update the Commission Implementing Decision on UWB, CEPT will also provide a report to the Commission with all the technical parameters required to amend the Decision.

Justification

Pursuant to Article 4(2) of the Radio Spectrum Decision, the Commission may issue mandates to the CEPT for the development of technical implementing measures with a view to ensuring harmonised conditions for the availability and efficient use of radio spectrum necessary for the functioning of the internal market. Such mandates shall set the tasks to be performed and their timetable. Pursuant to Article 1 of the Radio Spectrum Decision, activities under the Decision must facilitate policy making with regard to the strategic planning and harmonisation of radio spectrum use as well as ensure the effective implementation of radio spectrum policy in the EU while serving the aim of coordination of policy approaches. Furthermore, they shall take due account of the work of international organisations related to spectrum management such as the ITU.

This permanent mandate follows the five previous Mandates given by the Commission to CEPT on UWB on 2004, 2005, 2006, 2008 and 2012, and seeks to support the objectives and integrate the work undertaken in these earlier mandates into a more regular and predictable framework for future updates. Stakeholders or ETSI may submit demands to access spectrum for UWB to CEPT. Any such request should be carefully analysed in order to assess whether the current technical conditions of the Commission Implementing Decision on UWB are able to respond to demand. Moreover CEPT when reviewing the framework, could make suggestions to improve it by removing frequency ranges from the list included in the technical annex, when required and duly justified (e.g. in case a particular use has become obsolete).

Objectives

In addition to the core objectives of the Commission Implementing Decision on UWB itself, the aim of this permanent mandate is to provide relevant technical information necessary to:

a) Update, whenever appropriate, the technical conditions in the technical annex of the Commission Implementing Decision;

b) According to market demand, this may include the identification of new frequency bands and/or new applications which should be added to the list included in the technical annex of the Commission Implementing Decision, in order to consolidate the Single Market through spectrum harmonisation. If needed, the deletion of entries in the technical Annex in case no demand has been identified.

Duration

c) This mandate will be kept as long as the Commission Implementing Decision on UWB is applicable;

d) However, the Commission, having received the position opinion of the RSC on that matter and with due consultation with CEPT, may terminate or modify this mandate at a specified point in time in case it would have become redundant, obsolete or needs to be updated.

Task Order and Schedule

CEPT is hereby mandated to undertake all the activities required to assess specific technical compatibility issues between UWB applications (generic and specific) and potentially affected selected radio services and radio applications, based on realistic interference scenarios, with a view to setting spectrum usage conditions which allow the use of UWB equipment without creating harmful interference to existing radiocommunication services and radio applications.

In agreeing technical solutions, the utmost consideration should be given to the benefits for consumers of the lower cost of products instigated by global harmonisation and by the avoidance of undue equipment fragmentation or operational restrictions.

CEPT is requested to collaborate actively with the European Telecommunications Standardisation Institute (ETSI) which develops harmonised standards for conformity under the Radio Equipment Directive and to take into account emerging technologies and ETSI (harmonised) standards.

In particular, CEPT is tasked to:

- identify and submit appropriate technical parameters, where needed, for additional UWB applications where a common approach could be beneficial to the EU internal market;
- identify and submit proposals, where needed, for updating technical parameters harmonised by the latest version of the technical Annex of the Commission Implementing Decision.

CEPT is mandated to provide deliverables according to the following preliminary schedule:

Delivery date	Deliverable	Subject
1st November 2018 and in principle every 2 years subject to CEPT's assessment of the need to update the UWB Decision	Report from CEPT to the Commission	All the technical parameters required to amend Decision (EU) 2019/785, to be presented.

In addition, CEPT is requested to report on the progress of its work pursuant to this Mandate in the relevant meetings of the Radio Spectrum Committee.

The result of this Mandate may be made applicable in the European Union pursuant to Article 4 of the Radio Spectrum Decision[1].

In implementing this Mandate, the CEPT shall take the utmost account of Union law applicable.

***

[1] Decision 676/2002/EC of the European Parliament and of the Council of 7 March 2002 on a regulatory framework for radio spectrum policy in the European Community, OJ L 108 of 24.4.2002, p.1.

ANNEX 3: LIST OF REFERENCES

[1] ECC Report 327: “Technical studies for the update of the Ultra Wide Band (UWB) regulatory framework in the band 6.0 to 8.5 GHz”, approved October 2021

[2] ECC Decision (06)04: "Harmonised use, exemption from individual licensing and free circulation of devices using Ultra-Wideband (UWB) technology in bands below 10.6 GHz”, approved March 2006, latest amended November 2022

[3] ECMA 368: "High rate ultra wideband PHY and MAC standard"

[4] ETSI TS 102 455 V1.1.1: "High Rate Ultra Wideband PHY and MAC Standard"

[5] IEEE Std 802.15.4a-2015: "IEEE Standard for Low-Rate Wireless"

[6] ETSI EN 302 665 V1.1.1: "Intelligent Transport Systems (ITS); Communications Architecture"

[7] IEEE Std 802.15.4z-2020: "IEEE Standard for Low-Rate Wireless Networks--Amendment 1: Enhanced Ultra Wideband (UWB) Physical Layers (PHYs) and Associated Ranging Techniques"

[8] Billy Verso: ”Next Generation UWB”, link, 21 January 2021

[9] Benjamin A. Rolfe: ”P802.15.4ab PAR Draft from MyProject”, link, 2 March 2021

[10] Project HIGHTS Deliverable 2.1 (March 2015): "Use cases and Application Requirements".

[11] ETSI STF565: “Specifications for the definition of the cooperative ITS Vulnerable Road Users (VRU) service”, link

[12] ITU Radio Regulations, Edition 2020

[13] ECC Report 64: “The protection requirements of radiocommunications systems below 10.6 GHz from generic UWB applications”, approved February 2005

[14] EU Directive 2014/53/EU: “Directive 2014/53/EU of the European Parliament and of the Council of 16 April 2014 on the harmonisation of the laws of the Member States relating to the making available on the market of radio equipment and repealing Directive 1999/5/EC”

[15] Recommendation ITU-R P.452-16: “Prediction procedure for the evaluation of interference between stations on the surface of the Earth at frequencies above about 0.1 GHz”

[16] Recommendation ITU-R P.2109-0: “Prediction of building entry loss”

[17] Recommendation ITU-R P.2108-0: “Prediction of clutter loss”

[18] ECC Decision (07)01: “Harmonised use, exemption from individual licensing and free circulation of Material Sensing Devices using Ultra-Wideband (UWB) technology”, approved March 2007, updated July 2022

[19] EN 302 065-1 V2.1.1: “Short Range Devices (SRD) using Ultra Wide Band technology (UWB); Harmonised Standard covering the essential requirements of article 3.2 of the Directive 2014/53/EU; Part 1: Requirements for Generic UWB applications”

[20] EN 302 065-2 V2.1.1: “Short Range Devices (SRD) using Ultra Wide Band technology (UWB); Harmonised Standard covering the essential requirements of article 3.2 of the Directive 2014/53/EU; Part 2: Requirements for UWB location tracking

[21] EN 302 065-3 V2.1.1: “Short Range Devices (SRD) using Ultra Wide Band technology (UWB); Harmonised Standard covering the essential requirements of article 3.2 of the Directive 2014/53/EU; Part 3: Requirements for UWB devices for ground based vehicular applications

[22] Decision 2007/131/EC: “ Commission Decision of 21 February 2007 on allowing the use of the radio spectrum for equipment using ultra-wideband technology in a harmonised manner in the Community”

[23] Researchgate.net: "Reducing Parking Space Search Time and Environmental Impacts A Technology Driven Smart Parking Case Study", /publication/345161862 (link)