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System Reference document (SRdoc);
Transmission characteristics;
Technical characteristics for level probing radar
within the frequency range 75 GHz to 85 GHz

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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 has been developed to support the co-operation between ETSI and the Electronic Communications Committee (ECC) of the European Conference of Post and Telecommunications Administrations (CEPT).

Modal verbs terminology

In the present document "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the ETSI Drafting Rules (Verbal forms for the expression of provisions).

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Introduction

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

LPRs as covered by ETSI EN 302 729 [i.4] are required to operate having a strict (stable) downward orientation of the antenna under any operating condition in combination with other antenna restrictions as e.g. beam width and gain.

As the half sphere concept which can be found in CEPT ECC Report 139 [i.2] has been verified by compatibility studies of LPRs with other radio services the present document aims to rely on this concept while showing that LPRs having other than the combinations of the antenna requirements and antenna position which can be found in ETSI EN 302 729 [i.4] will maintain a maximum e.i.r.p. on the half sphere of -41,3 dBm. For this reason the present document gives a set of pre-selected use cases each having different character well suited for its intended application.

The present document at hand requests for better fitting antenna requirements which are optimally adapted to the situations found in the field. Current LPRs contrary to expectations do not have sufficient capabilities tracking the level of the measured product in some applications. Particularly from applications where the level of solids has to be measured the LPR industry receives frequent customer complaints where instruments fail to measure an accurate level of the product. Additionally customers now demand for embedding a volumetric measurement into their e.g. materials management.

The need for adapting the restrictions on antenna orientation and antenna requirements for LPR radiodetermination devices was identified in order to cover measurement tasks which cannot be conducted adequately or cannot be conducted at all at the moment due to the limited antenna orientation capabilities and/or beam width.

Today's regulation with the requirement that the antennas need to point strictly downwards blocks either applications where tilting the antenna is required to get a sufficient receive signal or applications with electronical or mechanical beam steering. The antenna beam width limitation blocks applications with the usage of comparable systems using low gain antennae.

The present document requests mainly:

- More usable and application specific positions of the LPR antenna other than strictly pointing downwards.

- More usable and application specific requirements of LPR antennas in terms of e.g. beamwidth or side lobe suppression while maintaining the downward orientation towards the ground.

The appropriated compensation for each of the above mentioned requirements in order to stay with the half sphere concept can be found in detail in Table 2. The present document covers therefore the request for more relaxed antenna requirements, especially in terms of orientation and beam width for LPRs as radiodetermination applications using UWB technology within in the 75 GHz to 85 GHz range. The intention is to create a basis for the LPR industry to maintain and expand market access without loss of its customer satisfaction in this technology while still avoiding any harmful interference with other radio services.

Communications applications or hybrid applications as a combination of sensor and communications applications are not treated within the scope of the present document.

The half sphere concept as used by the current regulation has been established by ERM TG TLPR which now has merged into ERM TG UWB.

The present document was developed by ERM TG UWB. The information in it has not yet undergone coordination by ERM. It contains preliminary information.

1 Scope

The present document describes LPR radiodetermination applications within the frequency range 75 GHz to 85 GHz which may require a change of the present frequency utilization within CEPT. The described UWB radiodetermination applications for future systems are split into the following classes and use cases:

- Object detection and classification/characterization.
- Motion, speed and presence detection.
- Distance measurement.
- Contour detection of solid material heaps.

The present document includes in particular:

- Market information.
- Technical information including expected sharing and compatibility issues.

NOTE: The information on sharing and compatibility issues is required when new spectrum or new spectrum usage is requested.

- Regulatory issues.

2 References

2.1 Normative references

Normative references are not applicable in the present document.

2.2 Informative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

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

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] European Commission Decision 2013/752/EU of 11 December 2013 (amending Decision 2006/771/EC on harmonisation of the radio spectrum for use by short-range devices and repealing Decision 2005/928/EC).

[i.2] CEPT ECC Report 139: "Impact of Level Probing Radars Using Ultra-Wideband Technology on Radiocommunications Services", Rottach-Egern, February 2010.

[i.3] ETSI EN 302 372 (V2.1.1) (10-2016): "Short Range Devices (SRD); Tank level Probing Radar (TLPR) equipment operating in the frequency ranges 4,5 GHz to 7 GHz, 8,5 GHz to 10,6 GHz, 24,05 GHz to 27 GHz, 57 GHz to 64 GHz, 75 GHz to 85 GHz; Harmonised Standard covering the essential requirements of article 3.2 of the Directive 2014/53/EU".

[i.4] ETSI EN 302 729 (V2.1.1) (10-2016): "Short Range Devices (SRD); Level Probing Radar (LPR) equipment operating in the frequency ranges 6 GHz to 8,5 GHz, 24,05 GHz to 26,5 GHz, 57 GHz to 64 GHz, 75 GHz to 85 GHz; Harmonised Standard covering the essential requirements of article 3.2 of the Directive 2014/53/EU".

[i.5] ETSI TS 103 361 (V1.1.1) (03-2016):" Short Range Devices (SRD) using Ultra Wide Band technology (UWB); Receiver technical requirements, parameters and measurement procedures to fulfil the requirements of the Directive 2014/53/EU".

[i.6] ITU-R "Radio Regulations Articles" Edition of 2016.

[i.7] ETSI EN 305 550 (V2.1.0): "Short Range Devices (SRD); Radio equipment to be used in the 40 GHz to 246 GHz frequency range; Harmonized Standard covering the essential requirements of article 3.2 of the Directive 2014/53/EU".

[i.8] ETSI EN 303 883 (V1.1.1) (09-2016): "Short Range Devices (SRD) using Ultra Wide Band (UWB); Measurement Techniques".

[i.9] ERC Recommendation 70-03: "Relating to the use of Short Range Devices (SRD)"; 13 Oct 2017 edition.

[i.10] Sweden's Minerals Strategy: For sustainable use of Sweden's mineral resources that creates growth throughout the country.

[i.11] European Commission: "The raw materials initiative - meeting our critical needs for growth and jobs in Europe", COM(2008) 699, 2008. .

[i.12] ECC Decision (11)02: "Industrial Level Probing Radars (LPR) operating in frequency bands 6 - 8.5 GHz, 24.05 - 26.5 GHz, 57 - 64 GHz and 75 - 85 GHz".

[i.13] Recommendation ITU-R M.2057: 'Systems characteristics of automotive radars operating in the frequency band 76-81 GHz for intelligent transport systems applications'.

3 Definition of terms, symbols and abbreviations

3.1 Terms

For the purposes of the present document, the terms given in ETSI EN 303 883 [i.8], ETSI TS 103 361 [i.5] and the following apply:

Activity Factor (AF): activity factor of a radiodetermination device is usually defined as the ratio of active measurement periods t_{meas} (bursts, sweeps, scans) within the overall repetitive measurement cycle T_{meas_cycle}

Adaptive Power Control (APC): adaptive power control is an automatic mechanism to regulate the transmitter power. It is controlled by the received power within the total receiver bandwidth

blocking distance: minimum distance from the target to the antenna of a LPR sensor which is at least necessary in order to guarantee a reliable measurement

NOTE: If the distance to the target falls below the blocking distance, the measurement may fail because the sensor is less sensitive or "blind" at close ranges.

Duty Cycle (DC): product of the pulse repetition frequency (PRF) and the pulse duration t_{pulse}

equivalent isotropically radiated power (e.i.r.p.): product of "power fed into the antenna" and "antenna gain". The e.i.r.p is used for both peak and average power

Frequency Modulated Continuous Wave (FMCW): based on a periodically linear frequency sweep of the transmit signal. For distance measurement sensors often a sawtooth or a triangular modulation scheme is used

NOTE 1: By mixing the current transmit signal with the reflected signal the round trip time of the individual echoes and thus the distance of the different targets can be determined.

NOTE 2: Although the instantaneous bandwidth of a FMCW Radar is close to zero the recorded power versus time variation results in a wideband spectrum which is clearly not pulsed.

Stepped Frequency Continuous Wave (SFCW): transmitted frequencies are changed by incremental increase

NOTE: Although the instantaneous bandwidth of an SFCW Radar is close to zero the recorded power versus time variation results in a wideband spectrum which is clearly not pulsed.

3.2 Symbols

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

f_L	lowest frequency of the operating bandwidth
f_H	highest frequency of the operating bandwidth
t_{meas}	active measurement time segment
T_{meas_cycle}	overall repetitive measurement cycle time (including possible idle time segments)
t_{pulse}	pulse duration in a pulsed system or the duration of an individual frequency step in an SFCW modulation scheme

3.3 Abbreviations

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

AF	Activity Factor
APC	Adaptive Power Control
DAA	Detect And Avoid
DC	Duty Cycle
DUT	Device Under Test
e.i.r.p	equivalent isotropically radiated power
EESS	Earth Exploration Service Satellite
FMCW	Frequency Modulated Continuous Wave
FSL	Free Space Loss
IC	Integrated Circuit
ITU-R	International Telecommunication Union - Radio sector
LBT	Listen Before Talk
LPR	Level probing Radar
PRF	Pulse Repetition Frequency
RAS	Radio Astronomy Station
Rx	Receiver
SFCW	Stepped Frequency Continuous Wave
SRD	Short Range Devices
TC	Technical Commitee
TGU-WB	Task Group Ultra-Wide Band
TLPR	Tank Level Probing Radar
Tx	Transmitter
UWB	Ultra-WideBand

4 Comments on the System Reference Document

4.1 Statements by ETSI Members

No statements or comments have been issued by ETSI members.

5 Presentation of the UWB-LPR systems and technology

5.1 Use cases of LPR sensor systems

Microwaves travel at the speed of light and this speed is essentially constant under a variety of different environmental conditions. This makes the use of microwaves a very robust measuring principle which is preferred when high accuracy is required and environmental conditions, such as temperature, pressure, etc. may vary.

Some of the main advantages of microwave technology for all kinds of sensors are therefore:

- high measurement accuracy;
- high repeatability;
- robust measuring performance in a variety of environmental- and process conditions;
- high reliability;
- minimum or even no maintenance requirements and wear as a result of no moving parts;
- easy installation;
- non-contact measuring principle provides a high independency of ambient conditions or process properties,
- superior long-term stability resulting from self-calibration mechanisms since devices have always stable internal references which are independent of temperature or humidity;
- efficient handling of many devices due to the support of different interfaces;
- the antenna or the radome is usually very robust against contamination with dust, dirt or other adverse environmental influences.

All these factors combined provide a technology that over time has proven to bring improvements in environmental protection, human safety, accident prevention and avoidance as well as a more efficient and sustainable use of natural resources and higher quality of end-products in different manufacturing industries.

There are already commercially available sensors on the market which partly cover some. Level Probing Radars (LPR) [i.4] working for example in the frequency band 75 to 85 GHz.

- Tank Level Probing Radars (TLPR) [i.3].

More information about some already existing systems can be found in annex A.

As indicated in the scope of the present document the UWB-LPR radiodetermination applications for potential future systems are classified into the following use cases:

- Object detection and classification/characterization.
- Motion, speed and presence detection.
- Distance measurement.
- Contour detection of solid material heaps.

With industry 4.0 a tremendous increase of automation requirements is expected. More and more individualized products will be fabricated in high automated production lines which contain lots of compact and flexible production units. These production units will contain sensors for both the production processes and for reconfiguration and change. Due to flexible and frequent changes in the process, residuals of prior products and cleaning substances should be detected for example with very high accuracy and resolution in order to maintain product quality and production efficiency.

Electric mobility and energy revolution are given as e.g. one of the drivers of the fast growing mining and minerals business induced by the battery industry which is moving towards highly sophisticated technologies and seeks for e.g. vanadium and lithium which are mining minerals. At the same time mining companies - amongst others - are going to increase efficiency by a combination of modern technologies towards so called digital mines.

Other technologies as LASER, optical sensing, ultra-sonic or photogrammetry are prone to dust and to foggy conditions. Therefore LPRs are one of the core technologies for such industries as e.g. waste management, pulp and paper and agriculture.

5.2 Object detection

5.2.1 Contour detection

Imaging Radar systems are used for 3D visualizing of arbitrary surfaces and objects (contour detection). The principle can be utilized for example for precise volumetric measurements of different bulk solids stored in stockpiles such as sand, gravel, stones, wood chips, coal, corn, fertiliser, etc. These materials shape a characteristic angle of repose when stored on a stockpile.

With a one dimensional distance sensor measuring towards only a small area on the surface and assuming the surface to be flat, often the volume expansion of the whole stockpile cannot be determined with sufficient accuracy. This problem can be overcome by installing several distance measurement systems uniformly and densely distributed over the measuring surface. However, this solution is unfavourable in terms of costs and installation effort.

Therefore a single imaging Radar system installed in a suitable position can be used which generates an exact image of the surface contour. This facilitates the calculation of the residual volume on the stockpile.

Imaging Radar systems therefore often use beamforming techniques with phased array antennas providing control of the beam direction (beam steering) and pattern shape including the side lobes without the need for rotating the entire unit mechanically. Comparable technologies to beam steering are known and these ones are using rather low gain antennas but demand a higher processing power. Detailed technical characteristics are given in one of the sub-classes in clause 7.

The application environment can be indicated as outdoor industrial areas where aggregation effects are highly unlikely due to a low density of measuring sites, the increased FSL in the higher frequency bands as 75 GHz to 85 GHz and larger distances between individual sensors.

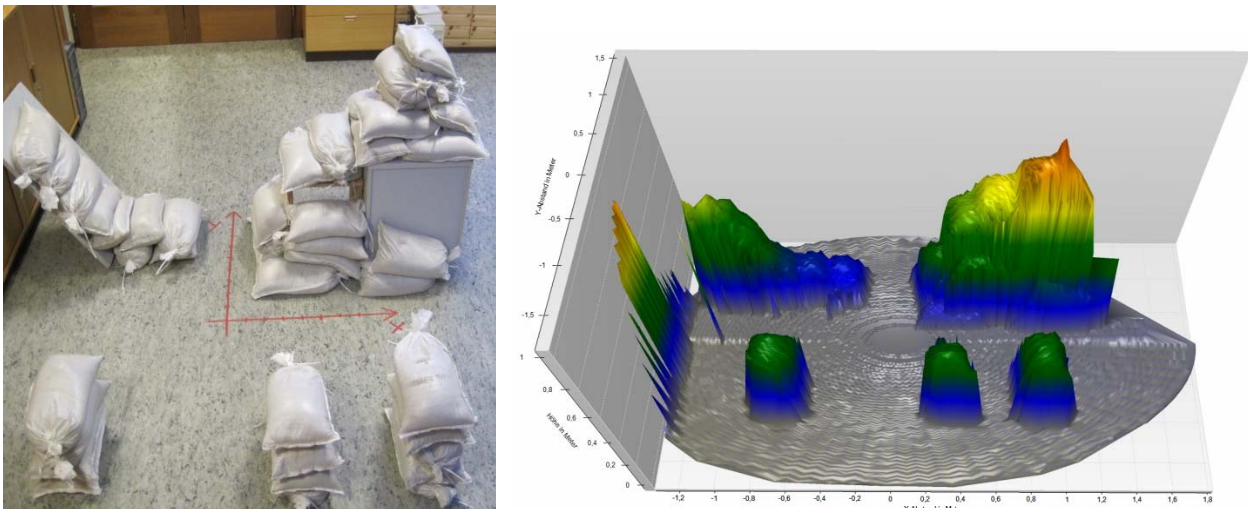

Figure 1: Measurement scenario with sandbags (left) and corresponding radar image (right)

5.3 Motion, speed and presence detection

5.3.1 Contactless flow measurement

The flow rate measurement in flumes, rivers and other running water bodies plays a prominent role for example in wastewater treatment, municipal water supply and especially in flooding prevention. With an accurate measurement of the flow rate in rivers in combination with the water level an exact flood forecasting is possible. This helps to take early measures against severe harm to infrastructure and people due to an impending flood.

The flow rate measurement sensor measures the speed of the waves at the surface of the flume for example by means of a doppler measurement and evaluation. Due to the fact that in most cases the width of the flume is known (dimension A in Figure 2) a simultaneous level measurement would be desirable in order to determine the depth (dimension B in Figure 2) of the watercourse. With the known cross section of the flume at the point of measurement the overall volume flow can therefore be calculated.

A disadvantage of today's sensor is the limited antenna position. This requirement blocks this application, where a radiation different from the strictly downward radiation is necessary.

The application environment can be indicated as outdoor remote rural areas and outdoor wastewater treatment plants where aggregation effects are highly unlikely due to a low density of measuring sites, the increased FSL in the higher frequency bands as 75 GHz to 85 GHz and larger distances between individual sensors.

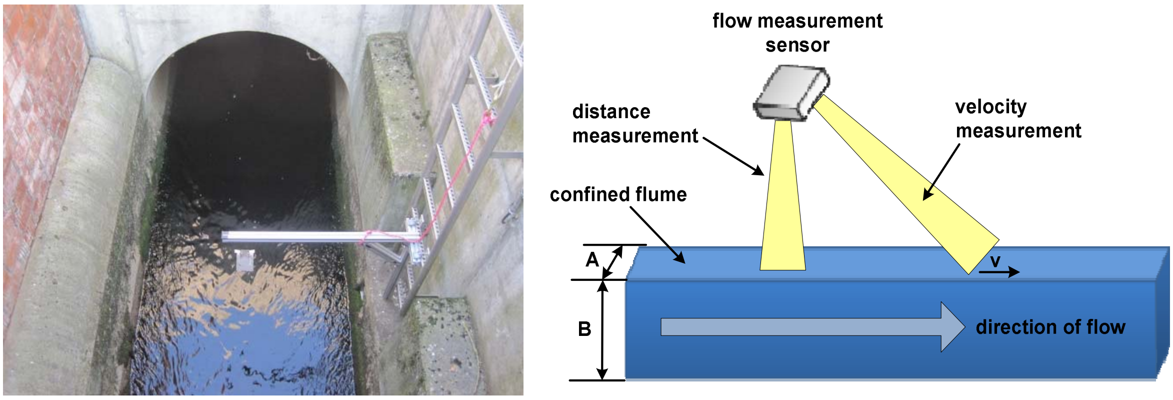

Figure 2: Contactless flow measurement in a confined flume

5.4 Distance measurement

5.4.1 Level probing on solid heaps having an angle of repose

The examples in clauses A.1.1 and A.1.2 show two use cases where Level Probing Radars can successfully be applied under harsh conditions.

However, there are still many measurement tasks which cannot be solved yet with the current available sensor technology. This is especially the case where the downwards antenna orientation does not allow to get sufficient signal energy reflected from the product. Problems may occur during filling the silos by lorries or belt conveyors where tracking of the radar-signal fails. Figure 3 shows a typical situation where the measurement benefits from a defined tilt angle of the instrument.

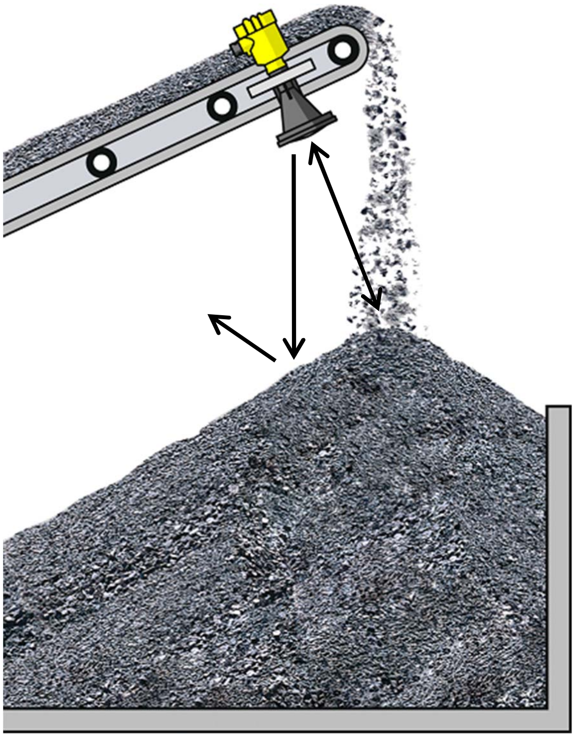

Figure 3: Illustration of an LPR bulk solid application where a defined tilt angle range of the antenna would be beneficial in terms of maximizing the receive signal at the LPR device

Furthermore it cannot not always be foreseen during installation of the instruments that the bulk material moves other than expected, gets dryer than expected, or changes it surface during processing.

For the above examples tilting the antenna to get more receive signal power is the only solution to overcome the problem without a cost intensive complete redesign of the bunkers.

The above mentioned requirements are still a big challenge for the existing LPR sensors in the established frequency bands. With a relaxed antenna main beam direction requirement within the frequency band 75 GHz to 85 GHz the above mentioned applications are easier to realize or can be realized at all. This also in turn enables new applications to be measured with microwave technology and furthermore the reliability of already existing distance measurement sensors can be improved in a whole slew of applications.

Figure 4 shows an example where an LPR sensor is mounted in a position to optimize the illumination of the product surface inside a feed hopper of an aggregate quarry. The quarry produces stones of different size (e.g. gravel) for the construction industry. In order to ensure the uninterrupted supply of stones to other sites of the quarry, the level of product inside the hopper and storage silo should be continuously monitored.

Table 1: Measurement conditions

Measurement conditions	
Measurement range	10 m
Process temperature	-20 °C to +50 °C
Process pressure	1 bar
Measurement difficulties	Changing product reflectivity, low-reflective medium (ε_r 1.6), dust and built-up creating antenna aperture layer, uneven and changing product surface with dedicated angle of repose.

Figure 4: Level measurement in a feed hopper

The application environment can be indicated as outdoor industrial areas where aggregation effects are highly unlikely due to a low density of measuring sites and large distances between individual sensors.

5.4.2 Low power level probing radars

As systems could be imagined as a mix of requirements taken from clause 5.3.1 and clause 5.4.1 leading to radars having extreme low power these ones will be also reflected by a category in clause 7.1.

These systems can have small antenna apertures resulting in wider beam angles. Wider beam angles are compensated by lower peak and mean e.i.r.p.

Applications are instruments for water and waste water, which is very cost sensitive. Advantage is that there is always a good reflection which means that antenna gain and power are reduced to still fulfil the radiated emission requirements on half sphere.

The application environment can be indicated as outdoor industrial areas where aggregation effects are highly unlikely due to a low density of measuring sites, the increased FSL in the higher frequency bands as 75 GHz to 85 GHz, larger distances between individual sensors and their extreme low transmitted power.

6 Market information

6.1 Overview

The provision of an expanded usage of the frequency bands 75 GHz to 85 GHz for applications like those identified in clause 5.1 but mainly for those in clause 5.2.1 goes along with the utilization of new semiconductor technologies. There are several chip manufacturers on the market with their highly sophisticated SOCs showing that the necessary semiconductor technologies are already available but the currently available frequency regulation is not yet usable for most of the proposed applications. The strictly pointing downwards antenna requirement and the antenna beam width limitation is in most cases not sufficient to solve the specific measurement task. The manufacturers of sensor equipment face therefore the current situation where a missing regulation constrains the development of new sensors although the technology is ready.

Therefore an exact market analysis and a prediction into the future are difficult at this particular early time. Finally the unit price of the Radar IC determines which applications can be covered at reasonable prices and thus the overall market potential. But on the other hand there can be found a high number of studies which are very good indicators that the world wide processes as e.g. in the mining and minerals industry clearly are unlocking a considerable market potential for systems introduced by clause 5.1. See Sweden's Minerals Strategy [i.10] and the second part of [i.11].

A distinct regulation for the mentioned applications in clause 5.1 enables the manufacturers to easily place their innovative products on the European market which otherwise would be difficult if not impossible and probably associated with a high risk for the individual company. Therefore it is expected that the overall market of those applications will rapidly grow in the beginning after a suitable frequency regulation is existent.

6.2 Market potential for contour detection instruments and LPRs

6.2.1 LPR

As LPRs operate in the range 75 GHz to 85 GHz with a short wave length of about 3,75 mm they are best suited to measure on solids compared to LPRs with lower frequencies and subsequently higher wave lengths. This is a result of the improved back-scattering at the granular surface of the solid materials. Nevertheless there are applications where also these systems fail and where antenna tilting, beam steering or a wider antenna beam width will significantly improve the measurement reliability and eventually will qualify certain systems for these applications.

Therefore the frequency range 75 GHz to 85 GHz is the preferred one to request more relaxed antenna orientation and beam width requirements.

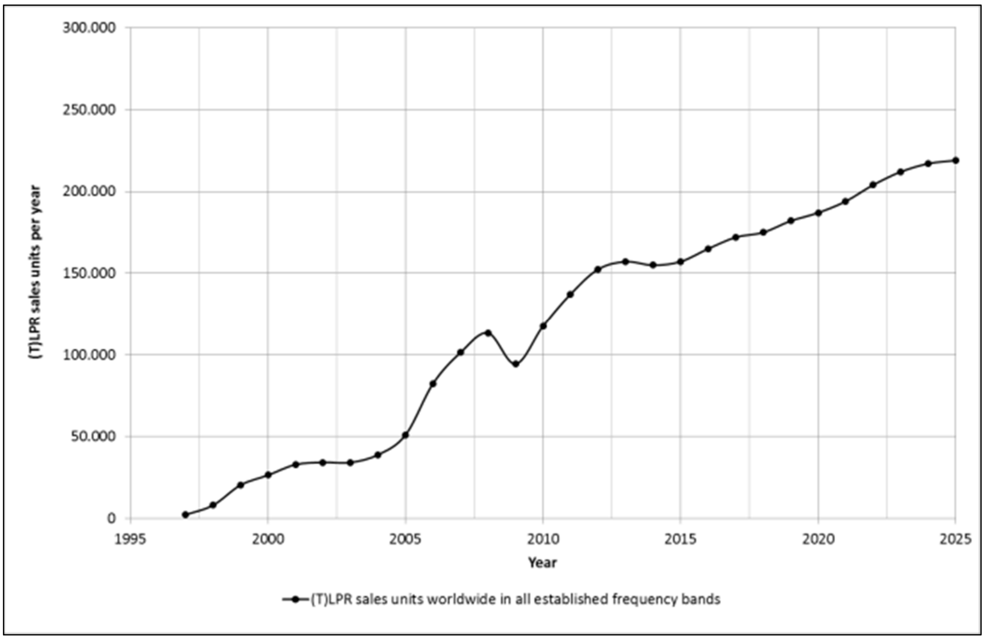

Figure 5: Total (T)LPR instrument sales (source: industry data)

As LPR users have put their trust in this news technology there is a risk that sales remain at the current level with LPR in the 75 GHz to 85 GHz range. Even there is a high risk to fail with further market success of these instruments if no significant improvement can be achieved by this request.

7 Technical information

7.1 Detailed technical description

7.1.0 General

The technical parameters in the following clauses 7.1.1 to 7.1.5 are applicable to all use cases identified in clause 5.1. It is proposed to divide the different applications into several categories relating to the severity of their interference potential to other spectrum users.

Table 2 gives information about use cases mapped to the best suited category of equipment. With the symbol "**x**" marked categories indicate the preferred ones whereas the "(x)" is considered a possible but not the optimal assignment to a category of equipment.

Table 2: Classification of Use Cases and Categories of Equipment

	Category A LPR	Category B LPR	Category C LPR
5.2.1 Contour detection	(x)		**x**
5.3.1 Contactless flow measurement	(x)	**x**	
5.4.1 Level probing on solid heaps having an angle of repose	**x**	(x)	
5.4.2 Low power level probing radars			**x**

Table 3 compares the several categories where the relationship to the current technical regulation ETSI EN 302 729 [i.4] is given. Table 3 entries having the grey background are fully in line with ETSI EN 302 729 [i.4] whereas the highlighted (white) fields show the differences which are requested and at the same time the proposed compensation to fulfil the half sphere limits. A detailed quantification is given by clause 7.1.1.

Table 3: Comparison of LPR categories

	Current LPR	Category A LPR	Category B LPR	Category C LPR
Antenna position	ETSI EN 302 729 [i.4] (Strictly Downwards)	Tilted	Tilted	Tilted
Antenna total opening angle	ETSI EN 302 729 [i.4]	ETSI EN 302 729 [i.4]	Wider	Much Wider
Maximum peak power (dBm, measured in 50 MHz) (within main beam)	ETSI EN 302 729 [i.4]	ETSI EN 302 729 [i.4]	Lower	Much Lower
Maximum Mean e.i.r.p. spectral density (dBm/MHz) within the LPR operating bandwidths (within main beam)	ETSI EN 302 729 [i.4]	ETSI EN 302 729 [i.4]	Lower	Much Lower
Mitigation techniques	ETSI EN 302 729 [i.4]	ETSI EN 302 729 [i.4]	ETSI EN 302 729 [i.4]	ETSI EN 302 729 [i.4]

Note that categories A, B and C do not introduce a new mitigation technique rather than proposing to use a good suited combination of mitigation techniques from ETSI EN 302 729 [i.4] to compensate the higher interference potential of a tilted antenna or a wider antenna opening angle, respectively.

This approach is well justified as using the ETSI EN 302 729 [i.4] has shown that applying a combination of the available mitigation technologies is sufficient to reach the ETSI EN 302 729 [i.4] limits.

Further it can be clearly shown that CEPT ECC Report 139 [i.2] already gives the option of other than pointing downwards antennae while maintaining the same low interference potential. Therefore mean e.i.r.p. limits depending on antenna characteristic and tilting angle are introduced in clause 7.1.1.

But of course as different radar technologies as e.g. pulsed systems or FMCW systems are on the market, the applicability of a set of different mitigation techniques should continue with this request.

Category C requests a wider antenna opening angle compared to the current regulation. But in contrast to category A and category B a much lower power in main beam direction is assumed to be sufficient to reach the goal of the appropriate use case.

The target is to ensure the same low emission levels on the half sphere as in the current regulation.

It is important to note that since LPRs are placed on a business-to-business market having direct distribution channels it can be expected that it is clearly possible for the manufacturers to have "old regulation"- alongside with "new regulation" – instruments in the field without any risk of mixing up the categories above.

Category A, B and C are intended for fixed outdoor applications where the sensors always radiate in a downward direction towards the ground (and thus not directly into the open sky) outside a shielded environment or a housing.

Type A, B and C applications are considered to be on a par with current LPRs in terms of interference.

Examples for categories A, B and C applications are given in Table 2.

The following technical parameters are divided into transmitter and receiver parameters (clauses 7.1.1 and 7.1.2) as well as into parameters for spectrum access (clause 7.1.3), antenna requirements (clause 7.1.4) and mitigation techniques (clause 7.1.5).

Suitable limits and regulations for all these parameters allow the limitation of the emissions and the mitigation of interference against other spectrum users as well as the definition of the resilience against interfering signals from other radio services.

7.1.1 Transmitter Parameters

7.1.1.1 Permitted frequency range of operation

The permitted frequency ranges of operation are the assigned frequency bands for the individual device under test.

There is no change of the assigned frequency bands as they are allocated in the current regulation of the European Commission Decision 2013/752/EU [i.1].

7.1.1.2 Operating bandwidth

The operating bandwidth includes all frequencies on which the equipment is authorized to operate within one or more of the permitted frequency ranges of operation. The operating bandwidth is measured for example as the 10 dB bandwidth.

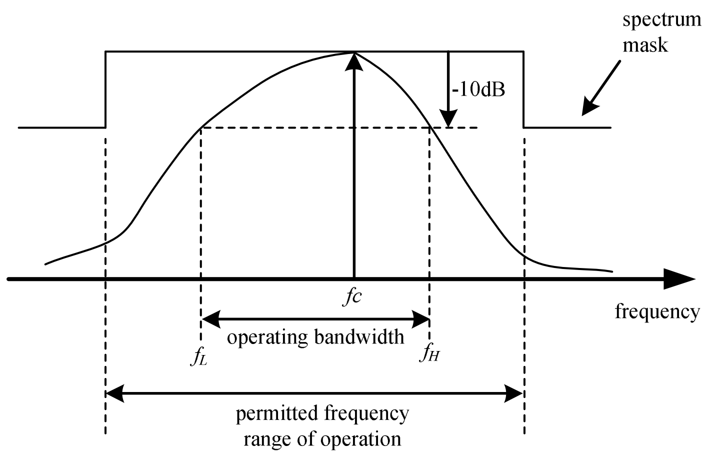

Figure 6: Definition of the operating bandwidth

7.1.1.3 Transmitter emissions within the operating bandwidths

The **maximum value of peak power** is defined as the equivalent isotropically radiated power (e.i.r.p.) contained in a 50 MHz bandwidth within the permitted frequency range of operation, radiated in the direction of main radiation (main lobe of the antenna).

The **maximum mean power spectral density (**specified as equivalent isotropically radiated power e.i.r.p.) of the radio device under test at a particular frequency is the average power per unit bandwidth centred on that frequency radiated in the direction of main radiation (main lobe of the antenna).

The maximum peak power and the maximum mean power spectral density can effectively be measured in the direction of main radiation of the antenna (main lobe direction) in a radiated test setup. These parameters can also be determined in a conducted test setup provided that the DUT exhibits a suitable antenna connector.

Based on the current available technologies the conducted peak power can reach values up to 10 dBm.

In the frequency ranges 75 GHz to 85 GHz compact antenna designs with a maximum gain of 40 dB are feasible, thus a maximum value of peak power of +34 dBm e.i.r.p. (measured in 50 MHz bandwidth) as in the current regulation 2013/752/EU [i.1] should be maintained.

For category A, B and C applications (Figure 9 and clause 7.1), the half sphere concept describes a practical approach to ensure for example the limitation of the maximum mean power spectral density (e.i.r.p), seen by a victim Rx antenna outside a half sphere area around the sensor installation, to -41,3 dBm (e.i.r.p), which is the same as in the current regulation ETSI EN 302 729 [i.4]. This value is equivalent to an electrical field strength of 500 µV/m in a distance of 3 m.

Inside the half sphere area and especially inside the shielded environment emissions higher than the proposed limit of -41,3 dBm (e.i.r.p.) may occur.

Due to the reflection accompanied by an attenuation of the Tx-signal at the surface of the target (Figure 9) or due to additional mitigation techniques the limit is fulfilled on any half sphere around the sensor installation where other spectrum users may be located.

The radius R of the half sphere (Figure 9) should be determined based on the operating frequency, sensitivity of the measurement equipment and with particular focus on the tilting angle.

As ETSI EN 302 729 [i.4] correlates the half sphere limits with the transmitter parameters a mean e.i.r.p. limit chart can be generated where the mean e.i.r.p. limit depends on antenna angle in combination with the appropriate tilting angles. Additionally Figure 3.1 of ECC report 139 [i.2] shows the applied use cases of LPRs where the side lobe level at ±24° of the LPR antenna has to be taken into account considering a dedicated angle of repose and downward orientation.

The resulting chart is given by Figure 8. Explanation of the formula symbols of Figure 7 can be found in the ECC report 139 [i.2].

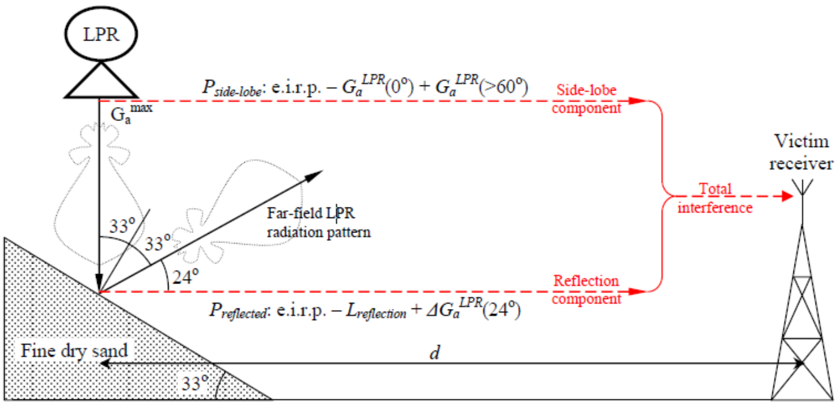

Figure 7: Configuration of considered worst case of LPR interference along terrestrial (horizontal) paths, figure taken from [i.2]

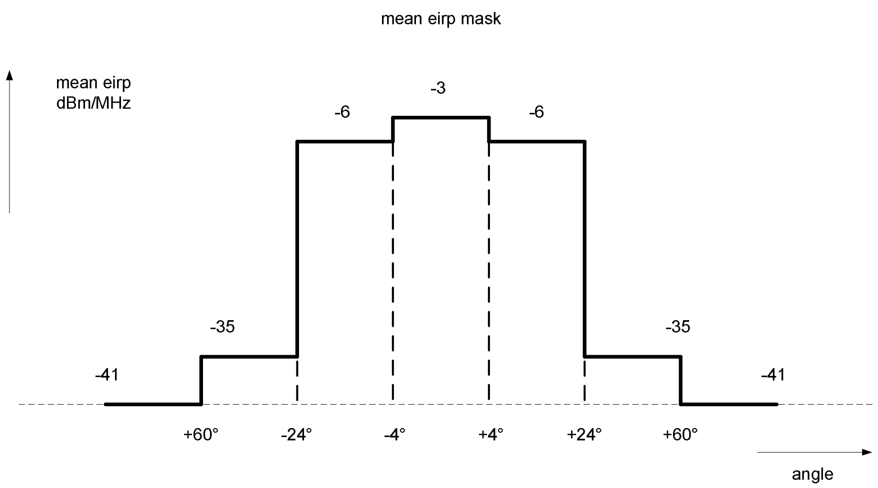

Figure 8: Mean e.i.r.p. mask

It should be noted that angles given by Figure 8 are not the ones of a LPR antenna alone rather than a superposition of tilting angle and the characteristics of the LPR antenna. Therefore the Figure 8 limits are valid for the complete instrument included installation setup.

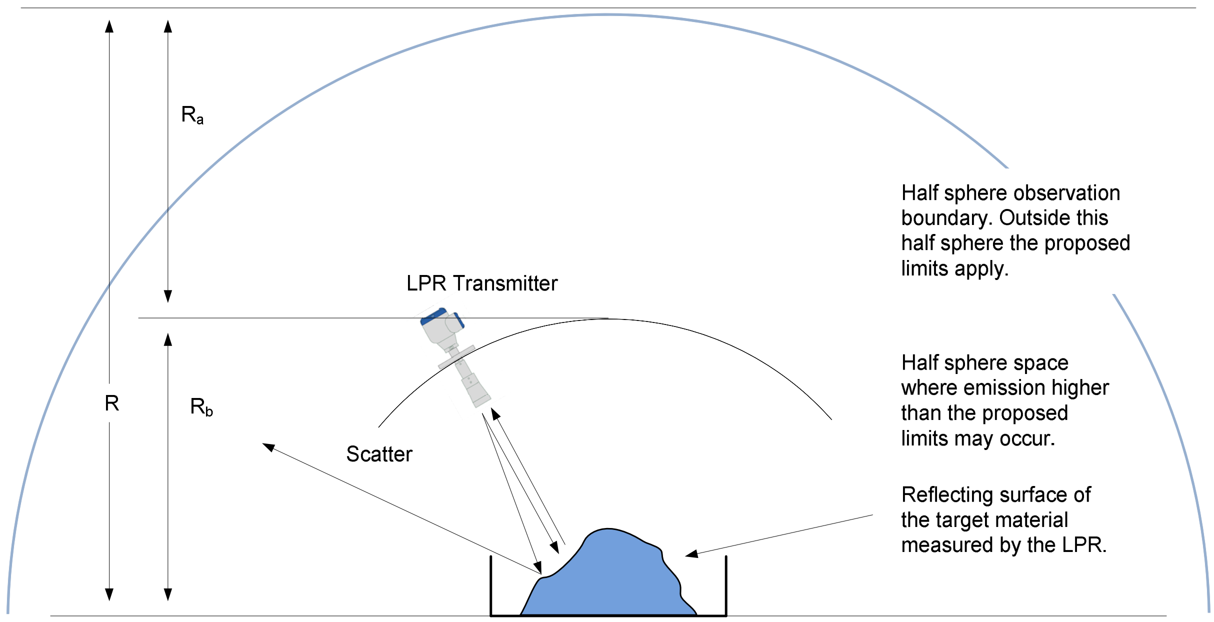

Figure 9: Illustration of the half sphere concept for applications with tilted transmitter

Figure 9 shows an LPR transmitter in a type A, B and C application with a tilted main beam direction. Limits for the tilting angle are proposed by Table 8.

Table 4: Technical Requirements for type A, B and C applications

Category	Maximum peak power (dBm, measured in 50 MHz) (within main beam)	Maximum Mean e.i.r.p. spectral density (dBm/MHz) within the LPR operating bandwidths (within main beam)	Maximum mean e.i.r.p. spectral density on half-sphere (dBm/MHz)
A	34	-3	-41,3
B	34	-10	-41,3
C	20	-20	-41,3

7.1.1.4 Transmitter (unwanted) emissions outside the operating bandwidths

The technical parameters in this clause are identical to those which can be found in ETSI EN 302 729 [i.4].

7.1.1.5 Other emissions

The technical parameters in this clause are identical to those which can be found in ETSI EN 302 729 [i.4].

7.1.2 Receiver Parameters

7.1.2.1 Receiver spurious emissions

The technical parameters in this clause are identical to those which can be found in ETSI EN 302 729 [i.4].

7.1.2.2 Interferer signal handling

The technical parameters in this clause are identical to those which can be found in ETSI EN 302 729 [i.4].

7.1.3 Requirements for spectrum access

7.1.3.1 Detect and avoid (DAA)

The technical parameters in this clause are identical to those which can be found in ETSI EN 302 729 [i.4].

7.1.3.2 Listen-before-talk (LBT)

The technical parameters in this clause are identical to those which can be found in ETSI EN 302 729 [i.4].

7.1.4 Antenna requirements

The restriction of the DUTs' antenna parameters and mean power requirements for type A, B and C applications are needed to fulfil the limits defined in the half sphere concept (see Figure 9) and thus effectively ensure the protection of other radio users from sidelobe emissions and reflections or scattering of the transmit signal from the surface or object under surveillance in a sharing environment.

Table 5: Side lobe mean power requirements depending on tilt-angle

	Current LPR	**Category A LPR**	**Category B LPR**	**Category C LPR**
Antenna position	Strictly Downwards	Tilted	Tilted	Tilted
Total effective angle In degree (°)	8	Limited to Figure 8	Limited to Figure 8	Limited to Figure 8
Maximum tilt-angle in degree (°)	0	±15	±30	±45
Antenna side lobe suppression relative to the main beam gain in elevation angles above x degrees (dB)	-38 Above 60 degrees	Limited to Figure 8	Limited to Figure 8	Limited to Figure 8
Instrument side lobe maximum mean e.i.r.p. spectral density (dBm/MHz) within the LPR operating bandwidths (see note)	n/a	-35 Above 9 degrees	-35 Above 0 degrees	-35 Above 0 degrees
	n/a	-41,3 Above 45 degrees	-41,3 Above 30 degrees	-41,3 Above 15 degrees
NOTE: The maximum mean e.i.r.p limits and the corresponding angles are derived from Figure 8 under consideration of the maximum tilt-angle.				

7.1.5 Mitigation techniques

7.1.5.0 General

The technical parameters in this clause are identical to those which can be found in ETSI EN 302 729 [i.4].

7.1.5.1 Adaptive power control (APC)

The technical parameters in this clause are identical to those which can be found in ETSI EN 302 729 [i.4].

7.1.5.2 Activity factor (AF) and duty cycle (DC)

The technical parameters in this clause are identical to those which can be found in ETSI EN 302 729 [i.4].

7.1.5.3 Frequency domain mitigation

The technical parameters in this clause are identical to those which can be found in ETSI EN 302 729 [i.4].

7.1.5.4 Shielding effects

The wall shielding of a tank or a pipe made out of metal, concrete or any other comparable attenuating material is an intrinsic mitigation factor for sensor installations in such environments. To ensure a proper shielding, sensor installations should comply with certain installation requirements.

Emissions caused for example by LPR installations in open-air environments can also be reduced by shielding due to special installation environments. For example boundary fences of bulk good heaps made out of metal or concrete or a floating roof tank inside a cylindrical metallic wall can serve in this case as additional shielding.

An additional shielding effect could be provided by the outer walls and other structures of a building if the device is only used indoors and the victim receiver is located outdoors. In the ECC Report 139 [i.2], the additional attenuation in case of indoor use is stated as 10dB at 7 GHz, 15 dB at 24 GHz, 20 dB at 57 GHz, 25 dB at 75 GHz.

Equivalent mitigation techniques which are currently not yet available can be taken into account as a placeholder. These hypothetical future mitigation techniques should be at least as effective as the demanded traditional ones and should result at least in the same mitigation factor.

In particular for type A and type A1 applications shielding effects are assumed to be defined.

7.2 Status of technical parameters

7.2.1 Current ITU and European Common Allocations

According to ITU Radio Regulations 2016 [i.6] the following allocations to services apply.

"66-81 GHz

Allocation to services		
Region 1	*Region 2*	*Region 3*
66-71	*INTER-SATELLITE* *MOBILE 5.553 5.558* *MOBILE-SATELLITE* *RADIONAVIGATION* *RADIONAVIGATION-SATELLITE* *5.554*	

71-74	*FIXED* *FIXED-SATELLITE (space-to-Earth)* *MOBILE* *MOBILE-SATELLITE (space-to-Earth)*
74-76	*FIXED* *FIXED-SATELLITE (space-to-Earth)* *MOBILE* *BROADCASTING* *BROADCASTING-SATELLITE* *Space research (space-to-Earth)* *5.561*
76-77.5	*RADIO ASTRONOMY* *RADIOLOCATION* *Amateur* *Amateur-satellite* *Space research (space-to-Earth)* *5.149*
77.5-78	*AMATEUR* *AMATEUR-SATELLITE* *RADIOLOCATION 5.559B* *Radio astronomy* *Space research (space-to-Earth)* *5.149*
78-79	*RADIOLOCATION* *Amateur* *Amateur-satellite* *Radio astronomy* *Space research (space-to-Earth)* *5.149 5.560*
79-81	*RADIO ASTRONOMY* *RADIOLOCATION* *Amateur* *Amateur-satellite* *Space research (space-to-Earth)* *5.149*

81-86 GHz

Allocation to services		
Region 1	*Region 2*	*Region 3*
81-84	*FIXED 5.338A* *FIXED-SATELLITE (Earth-to-space)* *MOBILE* *MOBILE-SATELLITE (Earth-to-space)* *RADIO ASTRONOMY* *Space research (space-to-Earth)* *5.149 5.561A*	
84-86	*FIXED 5.338A* *FIXED-SATELLITE (Earth-to-space) 5.561B* *MOBILE* *RADIO ASTRONOMY* *5.149*	

Footnotes:

5.149 *In making assignments to stations of other services to which the bands:*

13 360-13 410 kHz,	*4 950-4 990 MHz,*	*102-109.5 GHz,*
25 550-25 670 kHz,	*4 990-5 000 MHz,*	*111.8-114.25 GHz,*
37.5-38.25 MHz,	*6 650-6 675.2 MHz,*	*128.33-128.59 GHz,*
73-74.6 MHz in Regions 1 and 3,	*10.6-10.68 GHz,*	*129.23-129.49 GHz,*
150.05-153 MHz in Region 1,	*14.47-14.5 GHz,*	*130-134 GHz,*
322-328.6 MHz,	*22.01-22.21 GHz,*	*136-148.5 GHz,*
406.1-410 MHz,	*22.21-22.5 GHz,*	*151.5-158.5 GHz,*
608-614 MHz in Regions 1 and 3,	*22.81-22.86 GHz,*	*168.59-168.93 GHz,*
1 330-1 400 MHz,	*23.07-23.12 GHz,*	*171.11-171.45 GHz,*
1 610.6-1 613.8 MHz,	*31.2-31.3 GHz,*	*172.31-172.65 GHz,*
1 660-1 670 MHz,	*31.5-31.8 GHz in Regions 1 and 3,*	*173.52-173.85 GHz,*
1 718.8-1 722.2 MHz,	*36.43-36.5 GHz,*	*195.75-196.15 GHz,*
2 655-2 690 MHz,	*42.5-43.5 GHz,*	*209-226 GHz,*
3 260-3 267 MHz,	*48.94-49.04 GHz,*	*241-250 GHz,*
3 332-3 339 MHz,	*76-86 GHz,*	*252-275 GHz*
3 345.8-3 352.5 MHz,	*92-94 GHz,*	
4 825-4 835 MHz,	*94.1-100 GHz,*	

are allocated, administrations are urged to take all practicable steps to protect the radio astronomy service from harmful interference. Emissions from spaceborne or airborne stations can be particularly serious sources of interference to the radio astronomy service (see Nos. ***4.5*** *and* ***4.6*** *and Article* ***29****).(WRC-07).*

5.338A *In the frequency bands 1 350-1 400 MHz, 1 427-1 452 MHz, 22.55-23.55 GHz, 30-31.3 GHz, 49.7-50.2 GHz, 50.4-50.9 GHz, 51.4-52.6 GHz, 81-86 GHz and 92-94 GHz, Resolution* ***750 (Rev.WRC-15)*** *applies.(WRC-15).*

5.553 *In the bands 43.5-47 GHz and 66-71 GHz, stations in the land mobile service may be operated subject to not causing harmful interference to the space radiocommunication services to which these bands are allocated (see No.* ***5.43****).(WRC-2000).*

5.554 *In the bands 43.5-47 GHz, 66-71 GHz, 95-100 GHz, 123-130 GHz, 191.8-200 GHz and 252-265 GHz, satellite links connecting land stations at specified fixed points are also authorized when used in conjunction with the mobile-satellite service or the radionavigation-satellite service.(WRC-2000).*

5.558 *In the bands 55.78-58.2 GHz, 59-64 GHz, 66-71 GHz, 122.25-123 GHz, 130-134 GHz, 167-174.8 GHz and 191.8-200 GHz, stations in the aeronautical mobile service may be operated subject to not causing harmful interference to the inter-satellite service (see No.* ***5.43****).(WRC-2000).*

5.559A *(SUP - WRC-07).*

5.559B *The use of the frequency band 77.5-78 GHz by the radiolocation service shall be limited to short-range radar for ground-based applications, including automotive radars. The technical characteristics of these radars are provided in the most recent version of Recommendation ITU-R M.2057 [*i.13*]. The provisions of No.* ***4.10*** *do not apply.(WRC-15).*

5.560 *In the band 78-79 GHz radars located on space stations may be operated on a primary basis in the Earth exploration-satellite service and in the space research service.*

5.561 *In the band 74-76 GHz, stations in the fixed, mobile and broadcasting services shall not cause harmful interference to stations of the fixed-satellite service or stations of the broadcasting-satellite service operating in accordance with the decisions of the appropriate frequency assignment planning conference for the broadcasting-satellite service.(WRC-2000).*

5.561A *The 81-81.5 GHz band is also allocated to the amateur and amateur-satellite services on a secondary basis.(WRC-2000).*

5.561B *In Japan, use of the band 84-86 GHz, by the fixed-satellite service (Earth-to-space) is limited to feeder links in the broadcasting-satellite service using the geostationary-satellite orbit.(WRC-2000)".*

7.2.2 Sharing and compatibility studies already available

In ECC Report 139 [i.2] the impact of level probing Radars (LPR) using Ultra-wideband technology in all currently available frequency bands for LPR (see annex A.1) on radiocommunication services has been investigated. The studies in the frequency ranges around 24 GHz and 80 GHz with the Fixed Service, EESS passive and the radio astronomy could easily be used as reference for the request in the present document.

7.2.3 Sharing and compatibility issues still to be considered

The request in the present document is to stay with the current regulation and to be still in line with the half sphere concept. Therefore no compatibility issues are foreseen.

7.3 Information on relevant standards

Table 6: Information on relevant standards

Type	Application	Frequency Ranges [GHz]	ETSI Standard	Status	Remark	Responsible ETSI TC ERM
Generic	Short Range Devices (SRD)	40 to 246 GHz	ETSI EN 305 550 [i.7]	EN Approval Procedure (ENAP) started	RED compliant	TG28
SRD	Tank Level Probing radar (TLPR)	4,5 to 7 GHz, 8,5 to 10,6 GHz, 24,05 to 27 GHz, 57 to 64 GHz, 75 to 85 GHz	ETSI EN 302 372 [i.3]	Cited in the OJEU	RED compliant	TG UWB
SRD	Level Probing Radar (LPR)	6 to 8,5 GHz, 24,05 to 26,5 GHz, 57 to 64 GHz, 75 to 85 GHz	ETSI EN 302 729 [i.4]	Cited in the OJEU	RED compliant	TG UWB

8 Radio spectrum request and justification

The future use cases considered in the scope of the present document (see clause 5.1) can be rated as fixed or quasi-fixed radiodetermination applications and can be categorized into three types based on the severity of their interference potential.

- **Type A and B:** Fixed outdoor applications emitting in a downward direction towards the ground outside a shielded environment or housing.

EXAMPLE 1: See Table 2.

Table 7: Proposed limits for maximum peak power and mean power spectral density for type A and B applications

maximum peak power	34 dBm e.i.r.p.	In the direction of main radiation.
maximum mean power spectral density	-41,3 dBm/MHz e.i.r.p.	Outside a half sphere area around the sensor installation (Figure 9 Illustration of the half sphere concept for type A and A1 applications).

- **Type C:** Fixed outdoor applications emitting in a downward direction towards the ground outside a shielded environment or housing.

EXAMPLE 2: See Table 2.

Table 8: Proposed limits for maximum peak power and mean power spectral density for type C applications

maximum peak power	20 dBm e.i.r.p.	In the direction of main radiation.
maximum mean power spectral density	-41,3 dBm/MHz e.i.r.p.	Outside a half sphere area around the sensor installation (Figure 9).

Types A, B and C. Much experience is available from ECC Report 139, [i.2] and ECC/DEC(11)02 [i.12]. Type A, B and C applications are able to coexist according to ECC Report 139 [i.2] with the fixed service and radio astronomy service (RAS). However, maximum elevation angles of the antenna main beam direction relative to the strict vertical downward orientation should are determined by the document on hand. So, for the applications it should be no problem to use the bands listed under footnote 5.149 in clause 7.2.1 for the protection of RAS and also to use the bands under development for the fixed service.

9 Regulations

9.1 Current regulation

LPR are regulated by [i.1], [i.9] and [i.4]. A brief technical summary of the requirements is given by Table 9.

Table 9: Technical Requirements of ETSI EN 302 729 [i.4]

Max TX power e.i.r.p.	Max TX power e.i.r.p. mean	Outside Half sphere	Total Opening Angle	Antenna orientation	Mitigation
34 dBm/50 MHz	-3 dBm/MHz	-41,3 dBm/MHz	8°	Strictly downwards	ETSI EN 302 729 [i.4]

The half sphere concept is illustrated by Figure 10 and Figure 11.

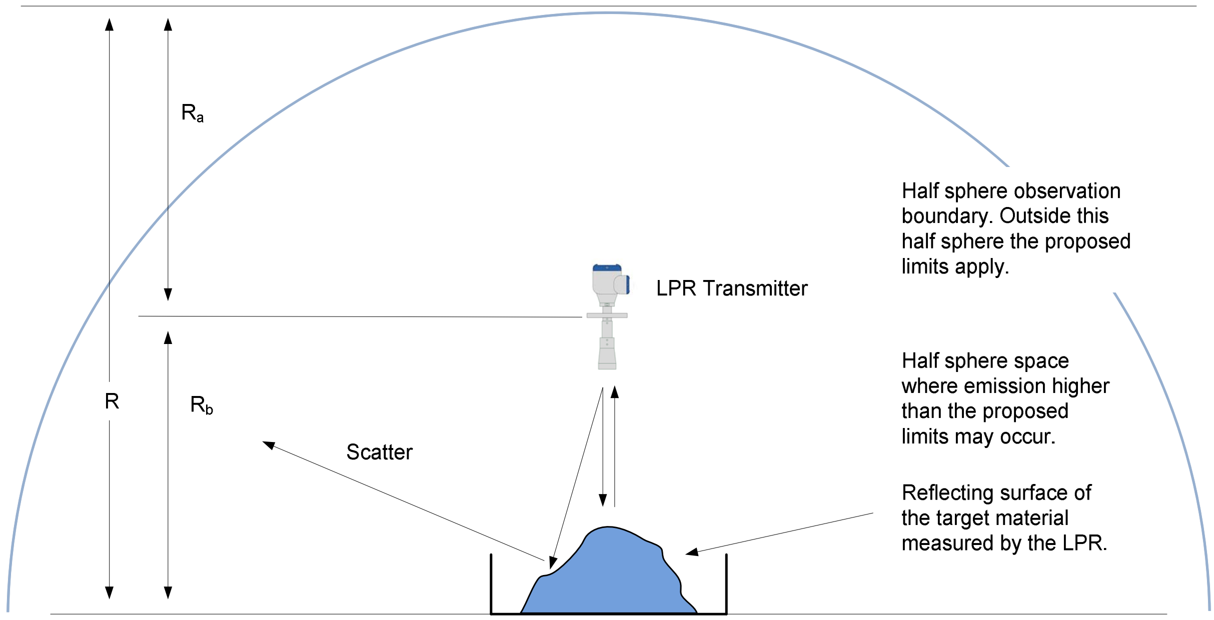

Figure 10: LPR Half Sphere Concept

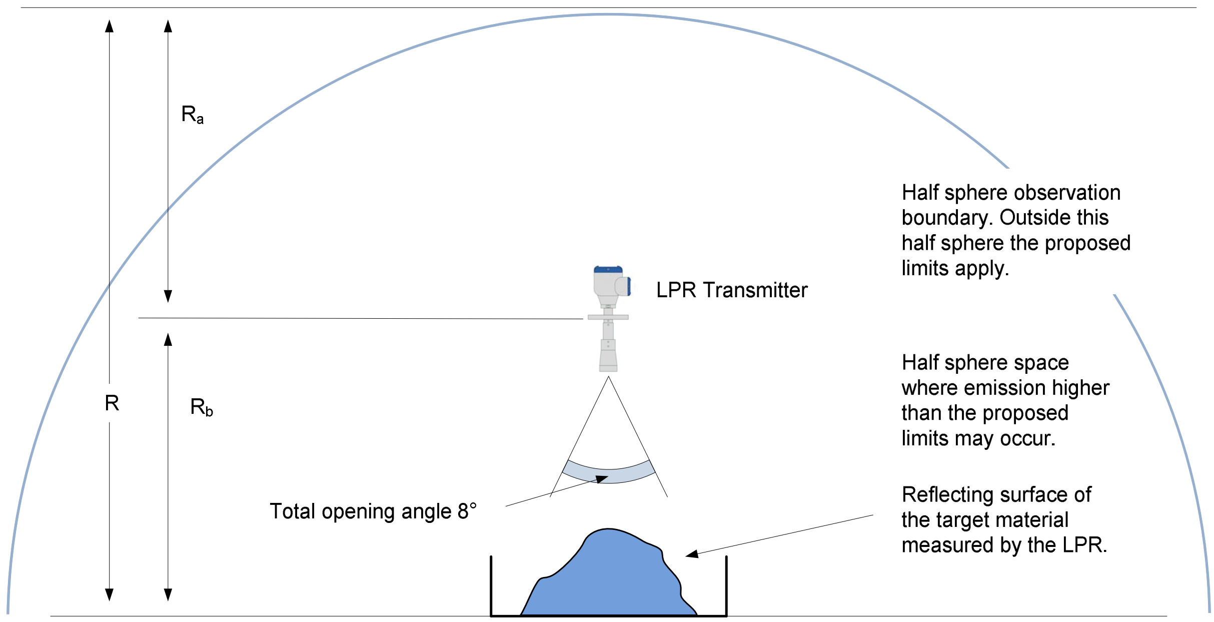

Figure 11: Total Opening Angle, 8° maximum

9.2 Proposed regulation

9.2.0 General

The deviations from total opening angle and/or from antenna orientation are fully in line with the results of the ECC report 139 [i.2] and does not have impact on the interference potential. But as the instrument characteristics and installation requirement are changed a revision of ECC Decision (11)02 [i.12] and 2013/752/EU [i.1] is expected.

Proposed changes to ECC Decision (11)02 [i.12] are shown in clause 9.2.1.

9.2.1 Changes to Annex 1 of ECC/DEC(11)02

Annex 1 of ECC/DEC(11)02 should be amended as outlined below (changes are highlighted in grey).

1) *"The technical requirements outlined in this Annex should be achieved under all circumstances. This means in particular that LPR devices shall operate only with dedicated/integrated certified antennas, which comply with the requirements for the maximum width of main beam specified in Table 1 (Column C) below;*

2) *Emissions of LPR devices shall comply with the mean e.i.r.p. spectral density and peak e.i.r.p. limits, specified in Table 1 (Columns A, B and D);*

~~*3) Strict (stable) downward orientation of LPR antennas under any operating conditions shall be ensured by appropriate installation;*~~

Table 1: Essential technical requirements for LPR devices

Frequency band	Antenna orientation and tilt angle	Maximum mean e.i.r.p. spectral density (dBm/MHz) (Notes 1 and 5)	Maximum peak e.i.r.p. (dBm measured in 50 MHz) (Notes 2 and 5)	Maximum antenna beamwidth (degree) ~~(Note 3)~~	Maximum mean e.i.r.p. spectral density on half-sphere (dBm/MHz) (Note ~~4 and~~ 5)
		A	B	C	D
6.0-8.5 GHz	Strict downwards +/- 0°	-33	+7	12 Note 3	-55 Note 4
24.05-26.5 GHz	Strict downwards +/- 0°	-14	+26	12 Note 3	-41.3 Note 4
57-64 GHz	Strict downwards +/- 0°	-2	+35	8 Note 3	-41.3 Note 4
75-85 GHz	Strict downwards +/- 0°	-3	+34	8 Note 3	-41.3 Note 4
75-85 GHz	Downwards +/- 15°	-3	+34	Note 6	-41.3 Note 6
75-85 GHz	Downwards +/- 30°	-10	+34	Note 6	-41.3 Note 6
75-85 GHz	Downwards +/- 45°	-20	+20	Note 6	-41.3 Note 6

Notes:

(1) Mean e.i.r.p. spectral density within LPR antenna mainbeam is the average power per unit bandwidth radiated in the direction of the maximum level;

(2) Peak e.i.r.p. within mainbeam is the power contained within a 50 MHz bandwidth at the frequency at which the highest mean radiated power occurs. If measured in a bandwidth of x MHz, this level is to be scaled down by a factor of 20log(50/x) dB;

(3) Defined by -3 dB level, relative to maximum gain. Note that in ETSI EN 302 729 expressed as ± HalfBeamWidth, here it is expressed as total opening angle. The LPR antenna gain in the elevation angles above 60 degrees from the main beam direction has to fulfil a maximum value of -10 dBi;

(4) The maximum mean e.i.r.p. spectral density limits on half sphere around LPR installation accounts for both the LPR antenna side-lobe emissions and any reflections from the measured material/object. Compliance with these limits is assumed in case LPR devices comply with measured maximum mean e.i.r.p. spectral density and the maximum peak e.i.r.p. limits within main beam (Table 1, Columns A and B) and use the prescribed antenna (see note 3);

(5) The related limits in unwanted emissions domain radiated by LPR are those as listed in Table 2 for LPR devices operating in the 6.0-8.5 GHz band. For LPR operating in the other bands, the limits for emissions in the unwanted emissions domain are at least 20 dB less than the in-band limits specified in Table 1. For LPR operating within the 24.05-26.5 GHz band, the unwanted emissions in the 23.6-24.0 GHz "passive band" are at least 30 dB less than the in-band limits specified in Table 1.

(6) The maximum mean e.i.r.p. spectral density limit on half sphere of -41,3 dBm/MHz e.i.r.p. around LPR installation accounts for both the LPR antenna side-lobe emissions and any reflections from the measured material/object under consideration of the maximum tilt-angle. The following additional maximum mean e.i.r.p. spectral density limits may be required for LPR applications with non-strict downwards orientation as an safeguard to avoid interference to radio systems (these limits were derived from the scenarios/studies in ECC Report 139 [i.2]. Note that column C requirements may be stricter than column A requirements):

-41,3 dBm/MHz e.i.r.p. above 60°, related to the vertical axis of the tilted LPR device

-35 dBm/MHz e.i.r.p. between 24° and 60°, related to the vertical axis of the tilted LPR device"

Table 2: Limits of unwanted emissions for LPR operated in 6.0-8.5 GHz band

Frequency range	Max. mean e.i.r.p. spectral density limit (dBm/MHz) (Note 1)	Max. mean e.i.r.p. spectral density limit on half-sphere (dBm/MHz) (Note 4)
Below 1.73 GHz	-63	-85
1.73-2.7 GHz	-58	-80
2.7-5 GHz	-48	-70
5-6 GHz	-43	-65
8.5-10.6 GHz	-43	-65
Above 10.6 GHz	-63	-85

Annex A:
Commercially available sensor systems

A.1 (Tank) level probing Radar

A.1.0 General

Today the use of Radar for distance measurement is a state-of-the-art technology and in many applications the most reliable and accurate measuring technique available. The development of such Radar sensors has been supported by the evolution of microwave technology over the last 25 years.

The currently available harmonised frequency bands for (T)LPR applications are summarized in Table A.1.

Table A.1: Current available harmonised frequency bands for (T)LPR equipment

Tank level probing Radar (TLPR)	Level probing Radar (LPR)
4,5 to 7 GHz	6 to 8,5 GHz
8,5 to 10,6 GHz	
24,05 to 27 GHz	24,05 to 26,5 GHz
57 to 64 GHz	57 to 64 GHz
75 to 85 GHz	75 to 85 GHz

Tank level probing Radar (TLPR) and level probing Radar (LPR) sensors are used in many industries concerned with process control to measure the amount of various substances (mostly liquids and solids). Due to different chemical or physical properties of different liquids or solids, (T)LPR sensors are installed in a large variety of different storage, processing or transportation containers including:

- metallic tanks or tanks made of similar material (tankers, concrete silos, etc.);
- non-metallic tanks (plastic, glass);
- open air (dams, pools, piles, rivers, channels, etc.).

In many of these installations, (T)LPR devices provide process- safety critical, real-time information to protect humans, equipment and the environment. Examples of process- safety critical applications include:

- hydrological services (river or dam levels, wave height, tides, etc.);
- storing or processing hazardous substances (flammable and/or corrosive substances, acids, bases, etc.);
- storing solids in piles (sand, pebble stones, gravel, coal, pellets, wood chips, etc.).

In other applications, an accurate level measurement helps to improve the quality of the end product, and to conserve the environment by facilitating the efficient use of scarce natural resources. Examples of such applications include:

- exact dosing of liquids in chemical or pharmaceutical plants;
- exact measurement of piles of solids (e.g. coal, iron ore, building materials like cement, etc.).

Most of the applications where (T)LPRs are used can be found in the following industries:

- chemical plants;
- petrochemical plants like refineries, fuel depots;
- pharmaceutical plants;
- food and beverage industry;
- power plants (oil, coal, woodchips, hydro, etc.);
- building materials;

- cement industry;
- metal production;
- water and sewage treatment;
- oil and gas offshore;
- paper production industry;
- recycling and waste treatment;
- hydrological services (river monitoring, wave height monitoring, tsunami warning, etc.).

The main purposes of using (T)LPRs are:

- to increase industrial efficiency, quality and process control;
- to increase reliability by preventing harm and damage to humans and infrastructure;
- to improve environmental conditions in industrial production processes;
- to improve the efficient use of natural resources and of scarce goods.

(T)LPRs are the preferred measurement tool to achieve the above goals for the following reasons:

- Non-contact measurement methods are needed to measure aggressive, corrosive or poisonous substances or substances in extreme temperature or pressure conditions or in explosive atmospheres.
- Radar sensor technology is very robust against contamination and other adverse process conditions (like temperature, pressure, dust, air turbulence, corrosiveness, viscosity, mechanical forces, etc.) while other alternative solutions like ultrasonic or optical sensors may often be too sensitive and vulnerable in harsh environments.
- Superb measurement accuracy and repeatability even in difficult environments.

A.1.1 Level measurement in wood pellet silos

Until they are delivered, wood pellets are stored in silos of corrugated sheet metal up to 30 m high. The large storage capacity allows the supplier to respond to the increased demand during the heating season and utilize their production equipment continuously throughout the year. Reliable measurement of silo contents is necessary for optimized planning of material logistics. Unaffected by dust, temperature fluctuations and the corrugated vessel walls, it detects the filling height of the pellets in the storage silos with good reliability.

Table A.2

Measurement conditions	
Measurement range	Up to 30 m
Process temperature	-20 to +40 °C
Process pressure	1 bar
Measurement difficulties	High dust levels, temperature fluctuations, corrugated container walls

Figure 12: Level measurement in a wood pellet silo

A.1.2 Sea level measurement at the harbour wall

Tsunamis travel quickly and cause great damage when they hit land. So it is vital that tsunami warnings are issued early. Tsunami information centres continuously evaluate simultaneous data from seismic and sea level measuring stations. Such a sea level measuring station is operated by an oceanographic centre in a ferry and cargo-ship terminal. The measurement has to reliably and accurately detect the sea level and forward the data directly to the central monitoring system.

Table A.3

Measurement conditions	
Measurement range	Up to 10 m
Process temperature	+4 to +20 °C
Process pressure	1 bar
Measurement difficulties	Aggressive seawater, outdoor use

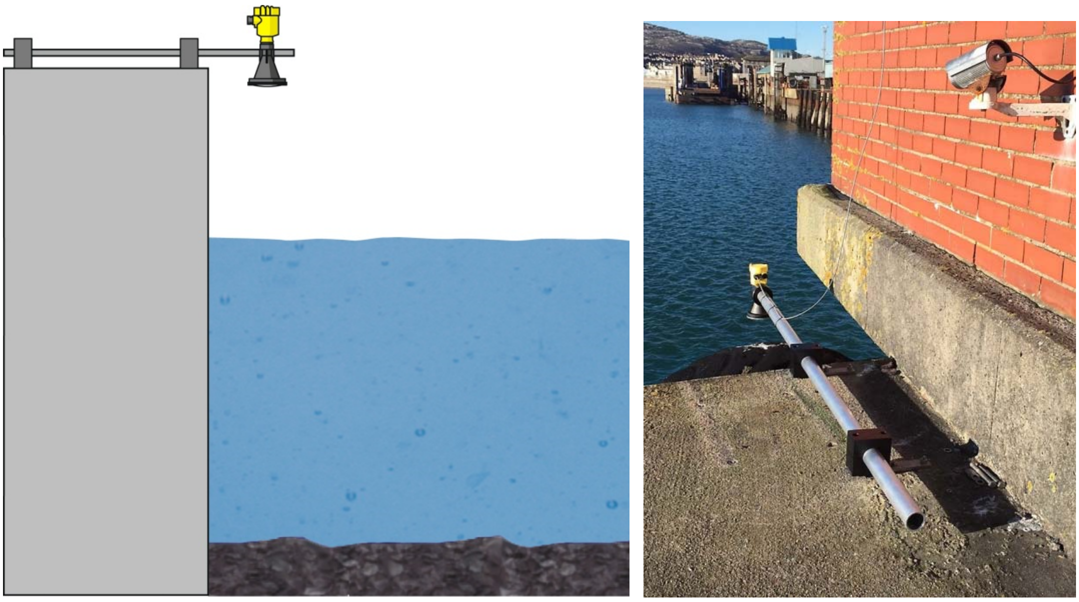

Figure A.2: Tsunami warning system at the harbour wall

Annex B: Bibliography

- ERC Recommendation 74-03 (2011): "Unwanted Emissions in the Spurious Domain", Cardiff.

Annex C:
Change History

Target version	Pre-approval date version (see note)			Date	Description
	a	s	m		
1.1.1	0.0.1			15.03.2018	Creation of the document prior to TG UWB #43
1.1.1	0.0.2			11.06.2018	Introduction of mean e.i.r.p mask
1.1.1	0.0.3			20.06.2018	Detailed tilt-angle and side lobe dependent mean e.i.r.p. limits added
1.1.1	0.1.0			21.06.2018	Stable draft for ETSI approval.
1.1.1	0.1.1			24.07.2018	Editorial changes Comments from BNetzA during RC. Clear description of the changes to the regulation in clause 9.2. Preparation prior to TG UWB #45b1
1.1.1	0.1.2			25.07.2018	Same as V1.1.1_0.1.1 *Track changes mode* activated and table 10 to be deleted.
NOTE: See clause A.2 in ETSI EG 201 788.					

History

Document history		
V1.1.1	April 2019	Publication