

**ELECTRONIC COMMUNICATIONS COMMITTEE**

ECC Decision  
of 1 December 2006  
on the conditions for use of the radio spectrum by  
Ground- and Wall- Probing Radar (GPR/WPR)  
imaging systems

(ECC/DEC/(06)08)



## EXPLANATORY MEMORANDUM

### 1 INTRODUCTION

UWB Ground- and Wall- Probing Radar (GPR/WPR) imaging systems have been used by professionals for over 30 years in several European countries in survey and detection applications.

GPR/WPR imaging systems have a significant effect on every day life such as locating underground gas main leaks, locating dangerous sink-holes, finding survivors of avalanches, surveying roads at normal traffic speeds, etc., while noting that a number of the radio services operating in the frequency bands covered by GPR/WPR are used for aviation, meteorology, defence, etc.

The European Telecommunications Standards Institute (ETSI) has developed ETSI Technical Report TR 101 994-2 (Technical characteristics for SRD equipment using Ultra Wide Band Technology (UWB), Part 2; Ground- and Wall-Probing-Radar applications) and the corresponding Harmonized European Standard EN 302 066 for GPR/WPR Radar applications which includes the technical characteristics and test methods for such equipment. The scope of ETSI EN 302 066 is limited to radars operated as short range devices (because of their usage and design), in which the system is in close proximity to the materials being investigated. It does not include radars operated from aircraft or spacecraft. In addition, highly specialized equipment using the frequencies typically below 100 MHz may use higher output power for geophysical applications (e.g. hydro-geophysical surveys).

GPR/WPR radar applications are not intended for communications purposes. Their intended usage excludes radiation into the free space and this should be avoided (e.g. a function which deactivates the equipment when normal use is interrupted).

The density of usage and activity is expected to remain low and therefore considerably reducing the risk of interference.

### 2 BACKGROUND

Ground Probing Radars (GPR) radiate directly downwards into the ground whereas Wall Probing Radars (WPR) radiate directly into a "wall". The "wall" is a building material structure, the side of a bridge, the wall of a mine or another physical structure that absorbs a significant part of the signal transmitted by the radar.

The emissions into the air resulting from the operation of GPR/WPR imaging systems (referred to within this Decision as "undesired emissions") are dependent on the operational conditions and are meaningful only if coupled with the material being investigated. GPR/WPR equipment normally uses integral antennas.

Taking into account expected mitigation factors like the very low density and activity factor, the deactivation mechanism (e.g. switch off the equipment when normal use is interrupted), the frequency dependency of wall and ground attenuation, then the risk of interference into any of the radio communication services is assumed to be low. It should be noted that GPR/WPR systems have operated for many years under interim arrangements, and no cases of harmful interference have been reported, although some of the radio applications (e.g. EESS in some band have not yet been deployed).

Currently, the licensing regime for imaging systems varies between administrations, with most handling the issue with experimental or short time licenses.

Administrations wishing to implement a national licensing regime may wish to use the guidance provided in the informative Annex 2 to facilitate the work of both administrations and GPR/WPR professional users in Europe.

A technical report on compatibility issues concerning GPR/WPR imaging systems has been developed within CEPT. While the performance of GPR/WPR operation are primarily driven by peak power emission levels, the parameter of importance with respect to the potential impact on radio services is the mean power.

The impact assessment on sensitive terrestrial stations - in particular on radars - took into account specific operational situations for GPR/WPR imaging systems and was focused on single interference analysis, and 100% activity factor.

The potential impact of GPR/WPR imaging systems on passive satellite services requires specific care, since coordination is only practical for terrestrial stations. The average power limit for the “undesired” radiated emissions is however the only effective mitigation factor with respect to the effect of single GPR/WPR equipment on passive microwave radiometers. The case of frequency band 1 400 – 1 427 MHz used by EESS (passive) observations appears to be most critical. It should also be noted that the RNSS receivers operating at 1.1 GHz, 1.2 GHz and 1.5 GHz have to be protected from spectral lines.

Measurements of the effective emissions radiated into the air have been undertaken in real operating conditions on different GPR/WPR equipments in order to balance where possible regulatory requirements with requirements for GPR/WPR operation.

Finally, it should be noted that a conversion factor (see Annex 1) has been established as a simple and practical way to assess mean power levels based on the measurement of peak power levels according to ETSI EN 302 066-1. The compliance to the mean e.i.r.p. density limits given in Annex 1 thus directly relates to the use of this conversion factor.

### **3 REQUIREMENT FOR AN ECC DECISION**

GPR/WPR imaging systems have been in use by professionals in Europe for many years in relatively small numbers. Operations have normally been performed under individual licenses, interim arrangements, licenses restricted to specific sites or other conditions. Therefore, license conditions vary from case to case and country-to-country. So far, harmful interference to other spectrum users has not been reported.

The requirement and purpose of this new ECC Decision is to provide a basis for a harmonized approach throughout Europe with regards to the regulatory environment for GPR/WPR imaging systems. This will reduce the burden of regulatory requirements from manufacturers and professional users as far as possible and will also lead to the creation of a common market for GPR/WPR equipment.

**ECC Decision  
of 1 December 2006**

**on the conditions for the use of the radio spectrum by Ground- and Wall- Probing Radar  
(GPR/WPR) imaging systems**

**(ECC/DEC/(06)08)**

“The European Conference of Postal and Telecommunications Administrations,

*considering*

- a) Decision ECC/DEC/(06)04 on the harmonised conditions for devices using UWB technology in bands below 10.6 GHz;
- b) that UWB technology is a technology used for short-range radiocommunication, involving the intentional generation and transmission of radio-frequency energy that spreads over a very large frequency range, which may overlap several frequency bands allocated to radiocommunication services;
- c) that CEPT can develop ECC Decisions for specific classes of devices using UWB technology which do not meet the technical requirements of Decision ECC/DEC/(06)04;
- d) that UWB technology has clear benefits for imaging applications;
- e) that imaging applications shall be understood as applications for the purpose of detecting or obtaining the images of objects buried into the ground or contained within a “wall”, or of determining the physical properties within the ground or a “wall”; the “wall” being a concrete structure, the side of a bridge, the wall of a mine or another physical structure that is dense enough and thick enough to absorb the majority of the signal transmitted by the imaging system;
- f) that Ground- and Wall- Probing Radar (GPR/WPR) imaging systems are using UWB technology and have been operated in Europe for many years under national interim arrangements without reported interferences to other spectrum users;
- g) that GPR/WPR imaging systems are operated in relative small numbers by trained professionals and their use can therefore be subject to individual licensing requirements;
- h) the need for an harmonized regulatory framework for the operation of GPR/WPR imaging systems in Europe;
- i) that the technical characteristics and test methods for Ground- and Wall- Probing Radar (GPR/WPR) applications operating in all or part of the frequency range from 30 MHz to 12,4 GHz are defined in ETSI EN 302 066-1;
- j) that requirements for the frequency range of operation, emission limits and deactivation mechanism are included in Harmonized European Standard ETSI EN 302 066-2;
- k) that GPR/WPR imaging systems operate on a non-interference, non-protected basis;
- l) that GPR/WPR imaging systems present the potential to transmit in bands allocated to passive services that are covered by RR footnote 5.340 which prohibits all emissions;
- m) that GPR/WPR imaging systems are normally designed to operate while in contact with, or in close proximity to the ground or the wall, and their emissions being directed into the ground or wall (e.g. measured by a proximity sensor or imposed by the mechanical design);
- n) that the reduction of the GPR/WPR undesired emissions is a specific design task for the manufacturers and that most of the GPR/WPR antennas are shielded to drastically reduce undesired emissions;
- o) that imposing power limits for the undesired emissions that are too stringent will severely limit performance of GPR/WPR systems;
- p) that the undesired emissions from the antenna/device, and/or scattered/reflected emissions from the ground or “wall”, and/or transmitted emissions through the “wall”; radiating into the air as a result of the operation of GPR/WPR imaging systems are highly dependent on the operational conditions and are only meaningful if coupled with the material being investigated;

- q) that for the purpose of this Decision, “undesired emissions” are defined as those emissions radiated in all directions above the ground from the GPR/WPR equipment, including direct emissions from the housing/structure of the equipment and emissions reflected or passing through the media under inspection;
- r) the need to further investigate within CEPT technical, operational and regulatory aspects relating to the concept of “undesired emissions” in order to address future systems referring to this concept;
- s) that a regulatory frame for the operational conditions needs to be defined so as to avoid misuse of GPR/WPR imaging systems;
- t) that a form of licensing would allow national administrations to limit the use of GPR/WPR imaging systems to professional users, and to provide co-ordination of GPR/WPR operation in the vicinity of sensitive radio sites and facilitate monitoring of their impact on radiocommunication services;
- u) that, in order to establish appropriate national licensing regime, the National Regulatory Authorities (NRAs) may wish to consider the guidance provided in Annex 2 of the Decision and in particular the authorisation prior to use GPR/WPR imaging systems in the vicinity of sensitive sites prior to their operation;
- v) that the impact of GPR/WPR imaging systems on radiocommunication services can be assessed on the basis of single interference studies, taking account of the relevant apportionment criteria of the maximum allowable interference;
- w) that co-ordination prior to the use of GPR/WPR imaging systems under an appropriate licensing regime may facilitate co-existence with terrestrial stations of radiocommunication services but is not effective when considering satellite receivers and, in particular, passive microwave sensors operated under the Earth Exploration Satellite Service;
- x) that, with regards to passive microwave sensors, an apportionment criterion of 1% for all UWB devices was applied in the coexistence studies to the maximum interference levels given in ITU-R Recommendation SA.1029-2;
- y) that administrations are encouraged to perform measurements of emissions from GPR/WPR imaging systems;
- z) that administrations are encouraged to collect evidence of any interference caused to incumbent services by UWB devices;
- aa) in EU/EFTA countries such systems or networks shall comply with the R&TTE directive.

#### DECIDES

1. that this ECC Decision defines harmonised conditions for the use of the radio spectrum by Ground- and Wall- Probing Radar (GPR/WPR) imaging systems in Europe;
2. that GPR/WPR imaging systems are defined as follows:
  - Ground probing radar (GPR) imaging system. A field disturbance sensor that is designed to operate only when in contact with, or within one meter of, the ground for the purpose of detecting or obtaining the images of buried objects or determining the physical properties within the ground. The energy from the GPR is intentionally directed down into the ground for this purpose.
  - Wall probing radar (WPR) imaging system. A field disturbance sensor that is designed to detect the location of objects contained within a “wall” or to determine the physical properties within the “wall”. The “wall” is a concrete structure, the side of a bridge, the wall of a mine or another physical structure that is dense enough and thick enough to absorb the majority of the signal transmitted by the imaging system;
3. that GPR/WPR imaging systems operate on a non-interference, non-protected basis;
4. that the use of GPR/WPR imaging systems shall be subject to an appropriate licensing regime;
5. that technical requirements for the operation of GPR/WPR imaging systems are detailed in Annex 1 of this Decision;

6. that this Decision enters into force on 1 December 2006;
7. that the preferred\* date for implementation of this Decision shall be 1 June 2007;
8. that CEPT administrations shall communicate the national measures implementing this Decision to the ECC Chairman and the Office when the Decision is nationally implemented.”
9. that based on the experience gained a review shall take place in 2010 and should include participation of all interested parties;”

Note:

Please check the Office web site (<http://www.ero.dk>) for the up to date position on the implementation of this and other ECC Decisions.

## Annex 1

**Technical requirements for the operation of GPR/WPR imaging systems**

1. GPR and WPR imaging systems shall be designed to operate while in contact with, or in close proximity to the ground or the wall, and their emissions being directed into the ground or wall (e.g. measured by a proximity sensor or imposed by the mechanical design).
2. GPR/WPR equipment shall have a deactivation mechanism of the equipment which is a function to deactivate the equipment when normal use is interrupted. This mechanism shall fulfil the following requirements:
  - Manually operated GPR and WPR, which is intended to be used as handheld equipment, shall contain a manually operated non-locking switch (e.g., it may be a sensor for the presence of the operators hand or a movement sensor) which ensures that the equipment de-activates (i.e. the transmitter switches off) within 10 seconds of being released by the operator.
  - In the case of remotely/computer controlled imaging equipment, the equipment is de-activated via the control system provided that de-activation takes place within 10 seconds of the control system being switched off or released by the operator.
  - There are particular cases where the equipment is mounted in a vehicle for the collection of data where the deactivation time required is 60seconds.
3. Maximum mean and peak power densities of any undesired emission emanating from GPR/WPR imaging systems are defined below. For pragmatic reasons and for taking the mitigation factors into account, the mean power density shall be determined by formula (1) or (2) below and the peak values shall be measured according to ETSI EN 302 066-1.

Note 1: GPR/WPRs operate across a wide range of spectrum where established radio services operate. These services have diverse bandwidths, some may be susceptible to peak signal levels and others to average signal levels. There are technical and practical issues, related to bandwidth, the effective loading of the GPR/WPRs radiation by earth materials and the limitations of instrumentation. It is acknowledged that peak signals levels will be measured and average signal levels calculated based upon the duty cycle of the GPR/WPR.

- a) The mean power density of any undesired emission emanating from GPR/WPR imaging systems shall be kept to a minimum and not exceed the limits in table 1, below:

<b>Frequency range (MHz)</b>	<b>Maximum mean e.i.r.p. density (dBm/MHz)</b>
<230	-65
230-1000	-60
1000-1600	-65*
1600-3400	-51.3
3400-5000	-41.3
5000-6000	-51.3
>6000	-65

\* In addition to the maximum mean e.i.r.p. density given in the table above, a maximum mean e.i.r.p. density of -75 dBm/kHz applies in the RNSS bands 1164-1215 MHz and 1559-1610 MHz in case of spectral lines in these bands

**Table 1**

- b) The measured radiated power density of any undesired emission emanating from GPR/WPR imaging systems shall not exceed the limits as given in table 2 below:

Frequency range (MHz)	Maximum peak power
30 to 230	-44,5dBm/120kHz (e.r.p.)
> 230 to 1 000	-37,5dBm/120kHz (e.r.p.)
> 1 000 to 18 000	-30dBm/MHz (e.i.r.p.)

**Table 2**

The method of measurements for peak power values are given by EN 302 066-1 V1.1.1, part 8.2.2.

- c) The time domain architecture of GPR/WPRs and patterns of use imply that there is wide variation in the total power emitted in any time period. For pulsed systems this includes the duration of pulses compared to the time between pulses, the time between bursts of pulses when the system is being moved to the next measurement position and other operational factors. This should be taken into account when considering the mean power that may be incident upon a vulnerable radio service. In order to accommodate all these factors a conversion factor is used to evaluate the mean power that should be compared to the limits in Table 1. This conversion factor has been established as a simple and practical way to assess mean power levels based on the measurement of peak power levels.

When determining mean power values, for pulsed systems, to be compared with the values in Table 1 the following formula shall be used:

$$(1) \quad \text{Power}_{\text{mean}} = \text{Power}_{\text{peak}} + \text{conversion\_factor}$$

$$\text{with:} \quad \text{conversion factor} = 10\log(\text{PRF} \times \tau)$$

where:

$\tau$  is the pulse width of the GPR transmitter measured at the 50% amplitude points of the envelope at boresight with an UWB probe and a suitable oscilloscope. When performing this measurement, care should be taken that the pulse is properly gated, i.e. no reflectors should be allowed to influence the pulse while travelling from the GPR transmitter to the UWB probe. The UWB probe/antenna should have a bandwidth wide enough to capture the UWB signal from the GPR/WPR properly.

PRF is the pulse repetition frequency.

For systems using step-frequency waveforms, the wideband signal is formed by transmitting a sequence of discrete frequencies each having a DwellTime (DT). The length of the total sequence is referred to as the ScanTime (ST). The Scan Time is identical to the Cycle Time in frequency hopping systems, and it is the interval between each time the transmitter is hopping back to the first frequency in the sequence.

For calculating the mean power value for a step-frequency system, the following formula shall be used:

$$(2) \quad \text{Power}_{\text{mean}} = \text{Power}_{\text{peak}} + \text{conversion\_factor}$$

$$\text{with:} \quad \text{conversion\_factor} = 10\log(\text{DT} / \text{ST})$$

where:

DT is measured at the 50% amplitude points of the envelope at boresight with an UWB probe and a spectrum analyser in zero-span mode at a frequency near the maximum of the radiated spectrum using 1MHz resolution bandwidth. ST is measured in the same way using a spectrum analyser in zero-span mode and 1MHz resolution bandwidth.

**Appendix 1 to Annex 1**

(Informative)

**Measurement of  $\tau$ , transmit pulse width.**

There are two ways of measuring  $\tau$ , time domain and frequency domain methods.

**1. Time domain.**

The GPR antenna is lifted off the ground and pointed directly towards the measurement antenna. The distance between the DUT and receive antenna shall be greater than one wavelength (at the lowest frequency radiated). Care is taken so that there are no unwanted multipath reflections included in the time interval where the pulse width measurement is carried out. The non-dispersive antenna/UWB-probe should have a fractional bandwidth wide enough to represent the UWB, signal (GPR/WPR typically have a fractional bandwidth greater than 100%).

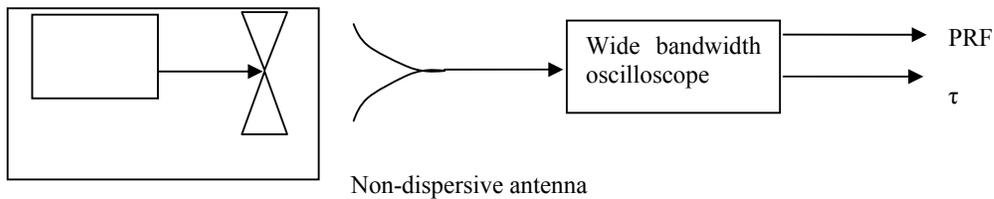


Figure 1: Test setup 1

**2. Frequency domain.**

The RF bandwidth of a single pulse modulated carrier is approximately  $=1/\tau$ . By measuring the occupied bandwidth an equivalent pulse width is calculated. There is no need to have a non-dispersive antenna or oscilloscope any more, the measurement is done with the same antenna and spectrum analyser as for the peak power measurement as per section 8.1 in EN302-066-01, but with the GPR and measurement antenna facing each other, see figure 2.

To avoid multipath reflections distorting the measurement, this test is carried out in an open test area or in an anechoic room.

$$\tau = 1/(F_{upper} - F_{lower}), \text{ -10dB measurement points.}$$

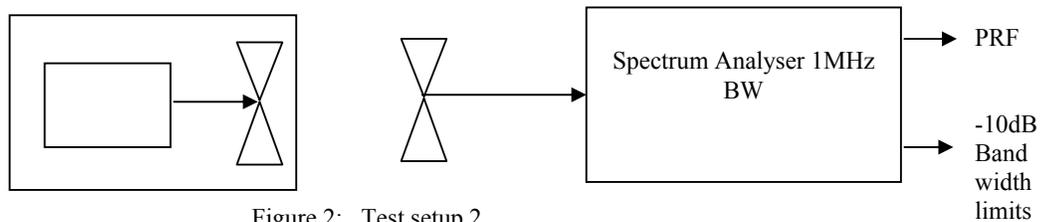


Figure 2: Test setup 2.

## **Annex 2**

(Informative)

### **Guidance to NRAs for establishing licensing and / or registration requirements for the use of GPR/WPR imaging systems**

#### **1. Introduction**

National Regulatory Authorities (NRAs) may establish individual licensing requirements for the use of the radio spectrum by GPR/WPR imaging systems as part of conditions for the efficient use of radio spectrum.

This purpose of this annex is to provide an example for the establishment of these individual licensing provisions so as to facilitate the work of both administrations and GPR/WPR professional users in Europe.

#### **2. Overall approach**

In addition to the harmonized technical requirements for GPR/WPR imaging systems, it is recommended that the national licensing regime include the following three individual requirements:

- Operator registration
- Notification prior to use in the vicinity of sensitive sites
- Yearly Log file to be kept by the user for inspection by the NRA

For management of associated procedures, NRAs may need to create databases for:

- GPR/WPR operators
- Sensitive sites

#### **3. Example of procedures**

##### **3.1 Operator registration**

Companies / organisations or individual operators must be registered at National Regulatory Authorities (NRAs) to be permitted to operate GPR/WPR imaging systems in European countries.

The application forms for **operator registration** of GPR/WPR imaging systems should be available on the Websites of the NRAs in both English and the administration national language.

⇒ An example for an Operator registration form in English is given below:

GPR/WPR imaging systems	Operator registration form
<b>Legal entity details</b>	
name:	
Activity:	
Mailing address:	
Country:	
Telephone:	
Fax:	
<b>Contact person for GPR/WPR operation activities (if any)</b>	
Last name:	
First name:	
Telephone:	
Fax:	
E-mail:	

⇒ NRAs should provide in return a national *Operator id.* as proof for registration and for reference in GPR/WPR operators database.

### 3.2 Example of notification procedure prior to use in the vicinity of sensitive sites

GPR/WPR operation may in some countries be subject to restrictions in some specific geographical areas. GPR/WPR operators need therefore to be able to verify prior to any field survey whether operation restrictions apply in their survey area.

Procedures for ‘Notification prior to use in the vicinity of sensitive sites’ rely primarily on the establishment by NRAs of a Sensitive sites database and associated query tool. For matters of safety and confidentiality, GPR/WPR operators may however not have access to the list of sites and all associated details.

As a minimum requirement, GPR/WPR operators should be able to query the database by entering survey area details (e.g. reference geographical coordinates + radius):

- In the absence of overlap of the ‘survey area’ with any ‘operation restricted area’, the query tool should respond that **no operation restrictions apply in the survey area**.
- In case of overlap of the ‘survey area’ with at least one ‘operation restricted area’, the query tool should respond that **operation restrictions apply in the survey area**. By default, the query tool could simply respond that operation is subject to authorisation in the ‘survey area’ and that notification to the NRA is mandatory prior to use. Next step procedures triggered by this notification could be standard national procedure applicable in case of request for temporary use.

Pending the level of information available in the Sensitive sites database, procedures for operation in a restricted area may be optimised site by site so as to minimize the number notification to NRAs, facilitate their treatment and as result reduce time to respond to GPR/WPR operators.

⇒ Sensitive sites databases can be built by NRAs using the following information sheet:

GPR/WPR imaging systems	Sensitive site information sheet
Site name:	
Site id.:	<i>(e.g. standard site id. referenced in national radio sites database)</i>
Owner:	
Mailing address:	
Country:	
Ref. geographical coordinates:	
Description of operation restricted area:	Radius from reference geographical coordinates (for example)
Procedure for operation in restricted area:	Notification to NRA for authorisation/ Operation forbidden (i.e. exclusion zone)/ Notification to Site contact person/ Other
<b>Site contact person (if any)</b>	
Last name:	
First name:	
Telephone:	
Fax:	
E-mail:	

⇒ In return of the query, and in case of restrictions in the survey area, the tool should inform GPR/WPR operators of the 'Procedure for operation in restricted area'.

Notification may thus be required so as to coordinate GPR/WPR operation in the vicinity of a sensitive site.

**Notification forms** prior to use of GPR/WPR imaging systems in the vicinity of sensitive sites should be available on the Websites of the NRAs in both English and the administration national language.

⇒ An example for Notification forms in English is given below:

<b>GPR/WPR imaging systems</b>	<b>Notification form for use in the vicinity of sensitive sites</b>
<b>Operator details</b>	
Company / Organisation name:	
Operator id.:	
<b>Contact person for GPR/WPR survey</b>	
Last name:	
First name:	
Mobile:	
<b>Survey area</b>	
Ref. geographical coordinates:	
Radius:	
General description & address:	
<b>Time period</b>	
Starting time (date):	
Ending time (date):	
<b>Description of GPR/WPR equipment 1</b>	
Brand:	
Model:	
Antenna type:	
Operating frequency range:	
Other:	

### 3.3 Log file by the user

A log should be kept by GPR/WPR operators of every occasion upon which a radar is used. The log could include the map reference of the location; details of the equipment employed particularly antenna details and the time and date of operations.

It is recommended that the same information as those required in the 'Notification form for use in the vicinity of sensitive sites' be recorded in such log file.

This provision is primarily meant to facilitate monitoring activities of administrations to monitor the impact of GPR/WPR imaging systems on radiocommunication services.