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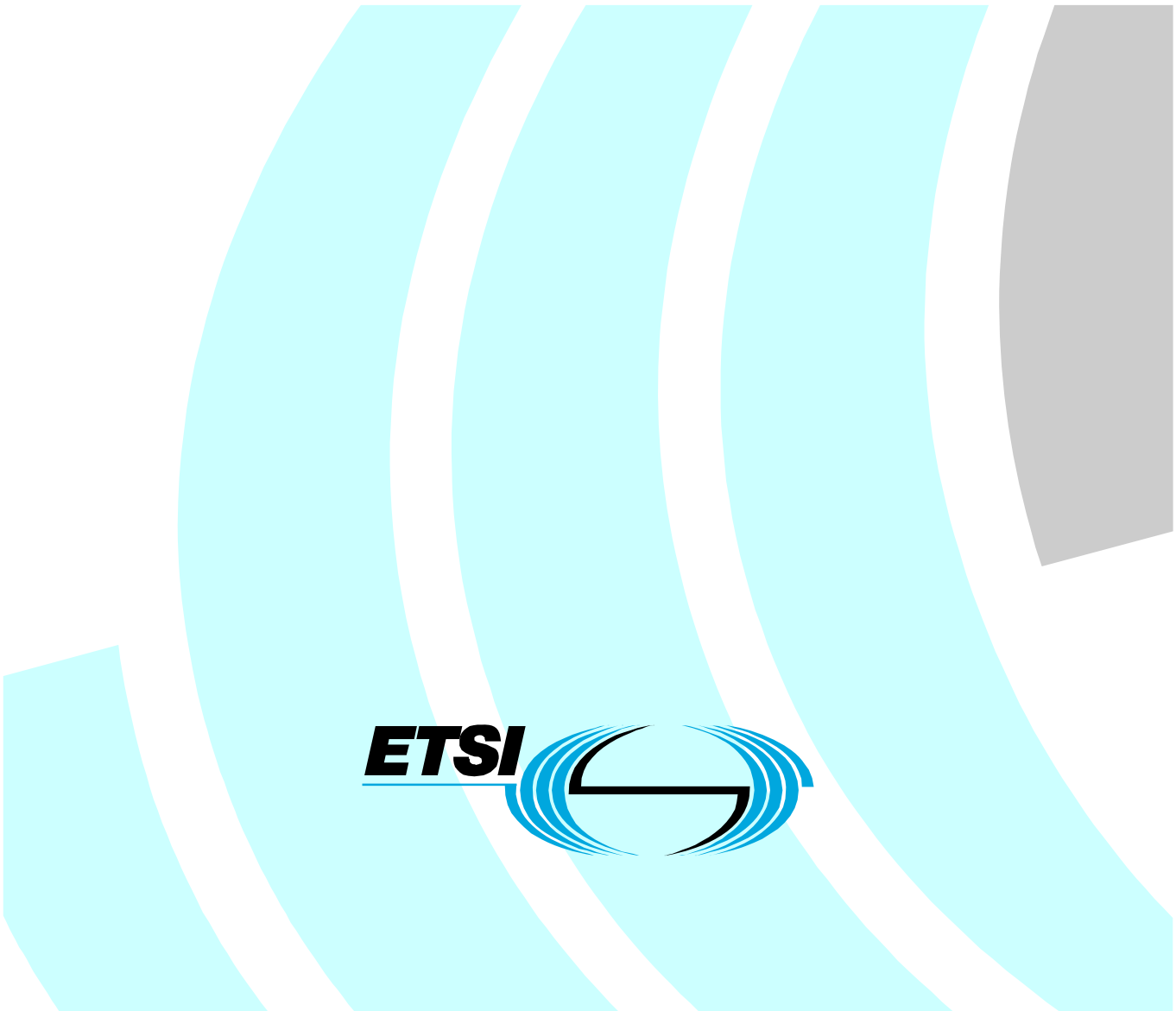
ETSI Guide

Electromagnetic compatibility and Radio spectrum Matters (ERM); Code of Practice in respect of the control, use and application of Ground Probing Radar (GPR) and Wall Probing Radar (WPR) systems and equipment



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Foreword

This ETSI Guide (EG) has been produced by ETSI Technical Committee Electromagnetic compatibility and Radio spectrum Matters (ERM), and is now submitted for the ETSI standards Membership Approval Procedure.

Introduction

The main objective of the present document is to set out a code of practice for the use and application of Ground Probing Radar (GPR) and Wall Probing Radar (WPR).

Ground Probing Radar (GPR) a well accepted geophysical method used to explore sub-surfaces. This technique has been in existence for more than 40 years, and has many beneficial uses in science, engineering, surveying, and maintenance of structures. Wall Probing Radar (WPR) has a similar history and is primarily used in the analysis of structures. Examples of the application of GPR/WPR are set out in annex A of the present document.

Unlike radio communication equipment/systems GPR/WPR does not radiate the wanted/necessary signal into the atmosphere, but into the sub-surface or a sub-structure The only signals which radiate into the atmosphere are those radiated /leaked from the structure/ housing of the GPR/WPR equipment and for best operating results these undesired emissions are kept to a minimum.

This equipment is subject to the R&TTE Directive 1999/5/EC [i.1] and the ETSI harmonized standards set out below may be used to demonstrate presumption of conformity, to the directive as follows:

- EN 301 489-1 [i.4] and EN 301 489-32 [i.5], to cover the requirements of Article 3.1b (Electromagnetic compatibility).
- EN 302 066-1 [i.2] and EN 302 066-2 [i.3], to cover the requirements of Article 3.2 (Frequency spectrum management).
- ETSI does not produce harmonized standards to cover Article 3.1a (Safety requirements), as this is the responsibility of the standards body CENELEC, but the CENELEC Generic standard EN 60950 [i.6] covering this subject may be used.

It is important to note that although meeting the requirements of the R&TTE directive 1999/5/EC [i.1] facilitates placing the GPR/WPR equipment on the market, it is still necessary to have authority to use the equipment in each individual country. Normally permission to use the equipment is via a licence, which is controlled by the country's government administration responsible for the administration of the frequency spectrum.

1 Scope

The present document sets out the code of practice for the control and application of Ground Probing Radar (GPR) and Wall Probing Radar (WPR) systems and equipment.

This type of equipment is normally used by competent professional personnel.

Applications of GPR/WPR are shown in the annex A.

The modern world relies on a wide variety of radio systems covering many diverse activities, ranging from systems on which safety of life depends, through to communications systems used scientifically, and commercially including the general public, broadcasting and many other applications. These diverse radio systems operate successfully together because compatibility requirements for each service have been carefully considered in terms of the planning of the radio frequency spectrum. Radio systems normally operate successfully together, but on occasions because of exceptional situations interference may occur. In this context GPR/WPR systems are no different to other radio systems.

The undesired radiation emitted from GPR/WPR systems have been carefully evaluated as part of the spectrum requirements and it has been demonstrated from practical use, that these systems are unlikely to cause interference to other radio systems.

This code of practice has been produced to ensure that interference from GPR/WPR systems to other radio systems is minimized, and that GPR/WPR users are made aware of the appropriate procedures set out in the present document.

2 References

References are either specific (identified by date of publication and/or edition number or version number) or non-specific.

- For a specific reference, subsequent revisions do not apply.
- Non-specific reference may be made only to a complete document or a part thereof and only in the following cases:
  - if it is accepted that it will be possible to use all future changes of the referenced document for the purposes of the referring document;
  - for informative references.

Referenced documents which are not found to be publicly available in the expected location might be found at http://docbox.etsi.org/Reference.

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

2.1 Normative references

The following referenced documents are indispensable for the application of the present document. For dated references, only the edition cited applies. For non-specific references, the latest edition of the referenced document (including any amendments) applies.

Not applicable.

2.2 Informative references

The following referenced documents are not essential to the use of the present document but they assist the user with regard to a particular subject area**.** For non-specific references, the latest version of the referenced document (including any amendments) applies.

[i.1] Directive 1999/5/EC of the European Parliament and of the Council of 9 March 1999 on radio equipment and telecommunications terminal equipment and mutual recognition of their conformity (R&TTE Directive).

[i.2] ETSI EN 302 066-1: "Electromagnetic compatibility and Radio spectrum Matters (ERM); Ground- and Wall- Probing Radar applications (GPR/WPR) imaging systems; Part 1: Technical characteristics and test methods".

[i.3] ETSI EN 302 066-2: "Electromagnetic compatibility and Radio spectrum Matters (ERM); Ground- and Wall- Probing Radar applications (GPR/WPR) imaging systems; Part 2: Harmonized EN covering essential requirements of article 3.2 of the R&TTE Directive".

[i.4] ETSI EN 301 489-1: "Electromagnetic compatibility and Radio spectrum Matters (ERM); ElectroMagnetic Compatibility (EMC) standard for radio equipment and services; Part 1: Common technical requirements".

[i.5] ETSI EN 301 489-32: "Electromagnetic compatibility and Radio spectrum Matters (ERM); ElectroMagnetic Compatibility (EMC) standard for radio equipment and services; Part 32: Specific conditions for Ground and Wall Probing Radar applications".

[i.6] CENELEC EN 60950: "Information technology equipment - Safety".

3 Definitions and abbreviations

3.1 Definitions

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

Ground Probing Radar (GPR): radar device which is used to explore sub-surfaces

Wall Probing Radar (WPR): radar device which is used for the analysis of sub-structures

3.2 Abbreviations

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

BW	Bandwidth
EMC	ElectroMagnetic Compatibility
GPR	Ground Probing Radar
IF	Intermediate Frequency
PL	Peak Level
PRF	Pulse Repetition Rate
RCS	Radar Cross-Section
τ	Transmitter pulse width
UHF	Ultra High Frequency
VHF	Very High Frequency
WPR	Wall Probing Radar

4 Recommended practice

4.1 General

GPR systems are designed to radiate low level signals into earth materials, typically the ground, or in the case of WPR into the concrete, brick or stone of a civil engineering or building structure. The overall objective of the present document is to ensure that radiation is directed into these materials and not into the atmosphere.

In order to realize this requirement care should be observed at all times when operating/using GPR/WPR equipment. There are also requirements in the organization of operations to allow potential interference incidents to be further investigated, and action on all parties involved to be agreed. It is recognized that it is important in the design of GPR/WPR equipment to ensure that the risk of interference to other radio services is minimized. Therefore while manufacturers have to meet set quantative performance standards, it is important that the operator/user understands the operational requirements necessary to keep interference to a minimum.

The following clauses set out the recommended operator/user practice, site use, site log and operational goals.

4.2 Operator practice

At all times operators/users should ensure that they follow the manufacturers instructions and minimize the chances of stray radiation as follows:

- That the GPR/WPR equipment/system or its transmitter is only switched on when carrying out measurements.
- That the GPR/WPR equipment/system contains a deactivation mechanism as defined in EN 302 066-1 [i.2], annex B, and EN 302 066-2 [i.3], clause 4.2.3.
- That whenever practical, to ensure that the GPR/WPR operating face is in contact with a layer of absorptive earth or structural material of sufficient thickness and properties to absorb and dissipate the GPR/WPR low level radiation.
- That prior to planned use of GPR/WPR equipment the user/operater should check that there are no sensitive radio sites/systems in the near vicinity (airfields, radio astronomy sites, etc.). These sites may be generally defined in the licence issued by the responsibly national administration. If these are present in the area, then liaison with the organization concerned should take place to obtain agreement, prior to any measurements being performed.

4.3 Site log

A log should be kept for every occasion when the GPR/WPR equipment is used. The log should include as a minimum the following:

- The map reference of the location.
- Brief description of measurements performed.
- Details of equipment used (manufacturer, model, serial number, nominal frequency(s) of operation) including the antenna details.
- Time and date of the operation/measurements.
- Ideally the log should be kept in electronic format, which is helpful in case of interference issues and is easily accessible by national government administrations responsible for administration of the frequency spectrum.

5 Sensitive Radio Environments

The most sensitive radio environments are those where the safety of life, or a similar function may be threatened if interference occurs to a radio system. Generally the areas of most concern are:

- Airfields.
- Prisons.
- Defense establishments.
- Radio astronomy sites.

When within 1,5 km of these or other sensitive locations, GPR operators should be particularly aware of the potential for interference and may be required to log details of the equipment, application and measurements to be used prior to be given clearance to operate.

In other locations the GPR operator may not be aware of other radio systems, but should observe the recommendations of this **Code of Practice** at all times. For example, aircraft "en route" systems that are not adjacent to airfields and may be screened by trees. Similarly a low flying aircraft may pass overhead at any time.

6 Product design guide

Manufacturers should ensure that GPR equipment are wherever possible designed to limit the possibility of interference to other radio systems and interference to the GPR systems from other equipment. Specifically all equipment coming into use should meet the requirements of the R&TTE directive 1999/5/EC [i.1]. In order to meet these requirements manufacturers should take the following into account:

- Wherever possible, design antennas that limit the radiation emitted in directions other than into the material under test.
- Design equipment to minimize the risk of inadvertent radiation occurring. This may be achieved by via the mechanical design of the equipment.
- The operating procedures may be defined by software, or simple devices such as proximity or tilt sensors.

Include a means for the time and date to be recorded of all GPR measurements made to aid the site log records.

Annex A:
Examples of applications for GPR/WPR equipment and systems

A.1 General

Current GPR practice includes applications occupying several octaves in the frequency range from 30 MHz to 6 GHz. This wide variation is not undertaken lightly but is specified predominantly by the propagation characteristics of the material through which the signal travels and the Radar Cross-Section (RCS) of the target sought. Earth materials generally act as a low pass filter to radio waves, with field sites often having a higher attenuation than the built environment, because in many cases the latter is sealed against the ingress of water which would increase attenuation; this becomes particularly relevant at the higher frequencies. The low frequency VHF applications are mostly used to maximize the depth of penetration in open field sites where the target may be an interface between two strata and its RCS is not highly frequency dependent. UHF frequencies are employed against such targets as pipes and cables where the RCS at low frequencies may be too small but the ground attenuation is not excessive. Microwave frequencies are used to find smaller objects at short range; the attenuation of the ground may become excessive but the lower attenuation of man-made materials (concrete, brick, etc.) may be helpful.

A.2 Examples of the characteristics of GPR/WPR for frequencies up to 1 GHz

Table A.1: Summary of typical technical characteristics of GPR/WPR

Frequency range	**VHF (30 MHz to 300 MHz)**	**Lower UHF (300 MHz to 600 MHz)**	**Upper UHF (600 MHz to 1 000 MHz)**	**Microwave (> 1 000 MHz)**
Typical PRF (Range)	50 kHz (50 MHz to 100 kHz)	100 kHz (50 MHZ to 500 kHz)	100 kHz (50 kHz to 2 MHz)	1 MHz (50 kHz to 10 MHz)
Pulse width	5 s	2 ns	~1 ns	<1 ns
Measurement BW and IF pulse width,τ	100 kHz 10 µS	100 kHz 10 µS	100 kHz 10 µS	1 MHz 1 µS
EN 302 066-1 [i.2] Limit dBm/BW (PL)	-44,5 (Quasi - Peak detector)	-37,5 (Quasi - Peak detector)	-37,5 (Quasi - Peak detector)	-30,0 (Peak)

A.3 Operational characteristics

Table A.2: Summary of operational characteristics of GPR/WPR

<table>
<tr><th>Attenuation characteristics of soil at various frequencies</th><th>100 MHz
10 dB/m to
30 dB/m</th><th>300 MHz
20 dB/m to
40 dB/m</th><th>500 MHz
30 dB/m to 60 dB/m</th><th>1 000 MHz
(Equal or greater)
40 dB/m to
80 dB/m</th></tr>
<tr><td rowspan="3">Typical Application</td><td colspan="2">Mostly used to maximize the depth of penetration in open field sites where the target may be an interface between two strata and its RCS is not highly frequency dependent.
Geophysical - Geological, Mining, Foundations, Land Management and Agriculture.</td><td></td><td></td></tr>
<tr><td></td><td colspan="2">Employed against such targets as pipes and cables where the RCS at low frequencies may be too small but the ground attenuation is not excessive
Civil Engineering Inspection, Utility Mapping, Archaeology.</td><td></td></tr>
<tr><td></td><td></td><td colspan="2">Used to find smaller objects at short range; the attenuation of the ground may become excessive but the lower attenuation of man-made materials (concrete, brick) may be helpful.
Highway and Runway Inspection, Detailed Structural Inspection, Anti-personnel Mine Detection.</td></tr>
</table>

History

Document history		
V1.1.1	July 2009	Membership Approval Procedure MV 20090911: 2009-07-14 to 2009-09-11