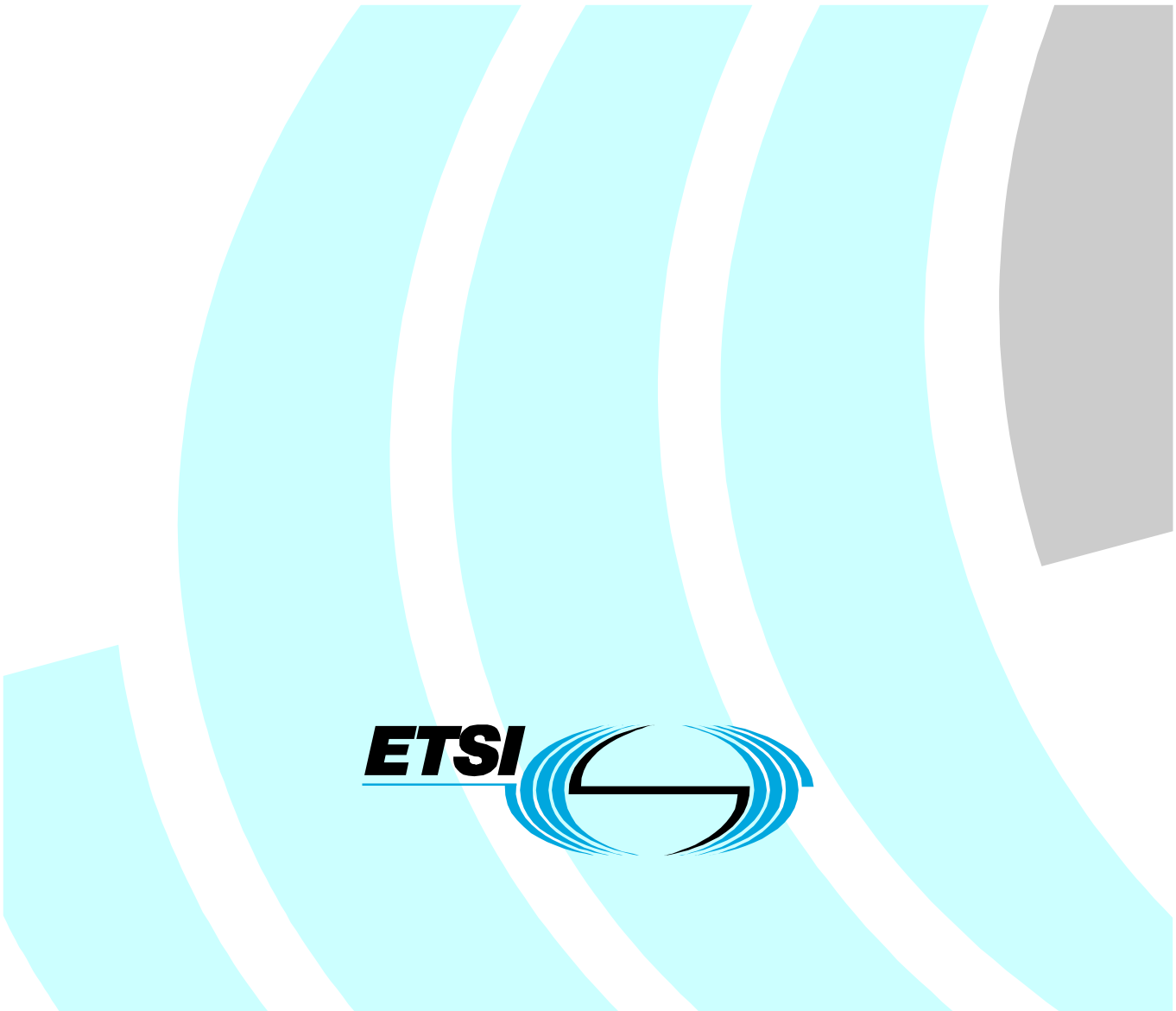
# ETSI TR 101 445 V1.1.1 (2002-04)

*Technical Report*

**Electromagnetic compatibility and Radio spectrum Matters (ERM); Short-Range Devices (SRD) intended for operation in the 862 MHz to 870 MHz band; System Reference Document for Radio Frequency Identification (RFID) equipment**



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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).

It includes necessary information to support the co-operation under the MoU between ETSI and the European Radiocommunications Committee (ERC) of the European Conference of Post and Telecommunications Administrations (CEPT) for amending annex 1 of the CEPT/ERC/REC 70-03 [1] for UHF frequencies as per the outcome of the DSI III conclusions and in support of the proposed UHF band plan for 862 MHz to 870 MHz by the LPRA and ISO/IEC JTC1/SC31/WG4.

# 1 Scope

The present document applies to RFID systems operating in the UHF band. RFID belong to the family of non-specific SRDs. It is anticipated that the frequency band proposed in the present document will be dedicated to non-specific SRDs. The present SR Doc is intended to define RFID systems that are used in item management and logistic applications. These applications require reading ranges of at least 2 m that cannot be provided by alternative technologies and at other frequencies.

The operation of SRDs in the UHF band is covered by the generic standard EN 300 220-1 [2]. Some of the requirements proposed in this System Reference Document - particularly those relating to power levels - fall outside the generic standard. It will be necessary therefore to raise a new Work Item for the generation of suitable documentation to deal with these issues.

The present document contains the technical characteristics for radio equipment referencing CEPT/ERC Decisions and Recommendation CEPT/ERC/REC 70-03 [1].

**Table 1**

| Power class | Power level (conducted or radiated) mW |
|---|---|
| 11 | 100 |
| 12 | 500 |
| xx | 2 000 |

The following information is given in the Annexes

- Annex A: Detailed market information;
- Annex B: Technical information;
- Annex C: Anticipated compatibility issues.

# 2 References

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

[1] CEPT/ERC/REC 70-03 (1998): "Relating to the use of Short Range Devices (SRD)".

[2] ETSI EN 300 220-1: "Electromagnetic compatibility and Radio spectrum Matters (ERM); Short Range Devices (SRD); Radio equipment to be used in the 25 MHz to 1 000 MHz frequency range with power levels ranging up to 500 mW; Part 1: Technical characteristics and test methods".

[3] ISO/IEC JTC1/SC31: "Automatic Identification and Data Capture Techniques".

# 3 Definitions, symbols and abbreviations

## 3.1 Definitions

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

**Adaptive Frequency Agile (AFA):** radio system that changes its operating frequency to suit the environment in which it finds itself

NOTE: AFA systems minimize the risk of interference between radio systems sharing common frequency bands.

**backscatter:** system where a *carrier signal* is propagated or induced and in which the direction of the incident waves from the *Interrogator/Reader* are resolved by a *Transponder* along a reference direction, and are reflected back in a reverse direction to the *Interrogator/Reader* in varying amplitude as the impedance of the transmitter is modulated using the same frequency or a harmonic of that frequency

**Battery Assisted Tag:** tag without an active transmitter, therefore still reliant on a technique such as backscatter, but that uses an on- board battery either to maintain on board power or boost the return signal

**Carrier Signal:** radio (or inductive) *signal* generated by the *Interrogator/Reader* and received by (or induced in) the *Tag* to initiate and conduct the *Transaction*, and, in the case of a *Passive Tag*, to provide the energy for the *Tag* to function

**Channel:** small frequency sub-band within the operating frequency band into which a *Radio Signal* fits

NOTE: Commonly, a *frequency band* is divided into contiguous channels.

**assigned frequency band:** frequency band within which the device is authorized to operate

**conducted measurements:** measurements which are made using a direct 50 Ω connection to the equipment under test

**dedicated antenna:** removable antenna supplied and type tested with the radio equipment, designed as an indispensable part of the equipment

**fixed station:** equipment intended for use in a fixed location

**full tests:** all tests specified in the present document

**integral antenna:** permanent fixed antenna, which may be built-in and is designed as an indispensable part of the equipment

**mobile station:** equipment normally fixed in a vehicle

**portable station:** equipment intended to be carried, attached or implanted

**radiated measurements:** measurements which involve the absolute measurement of a radiated field

**transponder**: a device that responds to an interrogation signal

**telemetry:** use of radio communication for indicating or recording data at a distance

**wide band:** equipment to be used in a non-channelized continuous frequency band covering more than 25 kHz, or to be used in a channelized frequency band with a channel spacing greater than 25 kHz

## 3.2 Symbols

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

| | |
|---|---|
| E | Electrical field strength |
| Eo | Reference electrical field strength |
| f | frequency |
| P | Power |
| R | distance |
| Ro | Reference distance |
| t | time |
| λ | Wavelength |
| Δr | Range resolution |

## 3.3 Abbreviations

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

| | |
|---|---|
| AFA | Adaptive Frequency Agile |
| ERC | European Radiocommunication Committee |
| FHSS | Frequency Hopping Spread Spectrum |
| GTAG™ | Global Tag. EAN●UCC compliant |
| R&TTE | Radio and Telecommunications Terminal Equipment |
| RF | Radio Frequency |
| Rx | Receiver |
| SRD | Short Range Device |
| UHF | Ultra High Frequency |
| RFID | Radio Frequency IDentificator |
| EAN | Electronic Article Numbering Association |
| UCC | Uniform Code Council |

# 4 Executive summary

RFID technology is used increasingly across a wide range of applications. There are many systems available operating at a number of different frequencies. The choice of frequency is a function of the specific application. For satisfactory operation in logistics and item management reading ranges of up to 2 m using passive tags are necessary. This is not feasible using either inductive or microwave RFID technology. However it is achievable at UHF.

This System Reference Document proposes UHF as the frequency best suited to the RF identification needs of the materials handling industry. This is because UHF offers low path loss and high data transmission speed combined with relatively low field strength. The tags can be produced in high volume at low cost and operate at high efficiency. The proposed frequency range and power levels will enable RFID tags to be deployed within the supply chain on a global basis in accordance with a single ISO standard.

UHF RFID tags can respond to frequencies anywhere within the band 860 MHz to 930 MHz. Therefore they can work with readers operating within the different UHF frequency bands assigned to SRDs by administrations in the three regions. In other words the same RFID tag can operate both in region 2 with a 902 MHz to 928 MHz FHSS reader and in region 1 where AFA readers operate in the 862 MHz to 870 MHz band.

The GTAG™ program aims to provide a global standard for the radio identification of goods moving in the supply chain. This necessitates the assignment of a UHF sub-band of 2 MHz to 3 MHz where frequency agile RFID systems can be used. These readers will use "listen before talk" techniques. This means that prior to the selection of a certain channel the reader will first check that it is not occupied by another device. If a channel is busy then the reader will search until it finds a channel that is unoccupied.

Frequency agile systems have been selected after carefully conducted tests. These compared different RFID modulation technologies such as wideband and FHSS systems with regard to compatibility with present users in the same or adjacent sub-bands. The results indicate that wideband frequency agile systems present least interference and highest spectrum efficiency.

The System Reference Document therefore defines the frequency and spectrum needs as well as power requirements. It further proposes that more complete compatibility studies should be carried out with other SRD equipment and services operating within the range 865 MHz to 868 MHz.

## 4.1 Status of the System Reference Document

This System Reference Document has been adopted by ETSI ERM.

## 4.2 Technical issues

**System description**

See clause B.1

**Applications**

See clause A.1

**New technology (if any)**

The UHF reader and tags use state-of-the-art technology and available chip designs.

**Short market information:**

Increasingly major manufacturers, distributors and retailers are seeking ways to reduce their costs of distribution. Many of these companies are beginning to see the benefits that can be achieved by utilising RFID. With the present state of the technology this is particularly relevant at the logistical asset level. These same companies have also seen the necessity for RFID to operate in accordance with an ISO/IEC 18000-6 (see bibliography) presently in work in ISO/IEC JTC1/SC31 [3]. This would permit goods to be distributed freely throughout the distribution chain on an international basis.

The Electronic Article Numbering Association (EAN) and the Uniform Code Council (UCC) is closely working with ISO on the realization of the standard and as a consequence the two organizations have jointly mounted the GTAG project in support of ISO/IEC 18000-6 (see bibliography).

During their initial assessment of the user requirement, EAN/UCC researched the global needs of the materials handling industry. As a result of their study they specifically rejected conventional bar codes and battery-assisted tags. The shipment of palletized loads is a physically demanding process during which damage is frequently inflicted on external packaging. To effectively withstand abuse, the means of identification must be positioned inside the load where it can be properly protected. Since line of sight is no longer possible bar codes cease to be an option.

In the case of battery assisted tags, end users had two fundamental objections. Firstly there is a practical problem in administering large populations of battery powered tags. Tagged items will frequently be dispersed around the world for extended periods outside the direct control of the owner. In such situations it will be impossible to manage the replacement of tags with dead batteries. Secondly end users were concerned about the additional associated cost - particularly where applications involved millions of tags.

As a consequence of this study EAN/UCC determined that passive tags operating at UHF most closely met the needs of their members.

**Market size, forecasts and timing**

See clause A.2, Market size and Volume

**Spectrum requirement and justifications**

In order to meet best the needs of the industry and the EAN and UCC members, the GTAG Project team investigated the use of RFID at different frequencies across the spectrum. The result of their investigation showed that operation at UHF offered a system with features that most closely met the market requirement. The reasons for reaching this conclusion are summarized below.

It is proposed that the band 865 MHz to 868 MHz be assigned to wide-band non-specific SRDs. The band would be divided into 15 channels of 200 kHz. This will allow SRD manufacturers to develop equipment that will operate at high data rates without interfering with existing users. The equipment will be restricted to either fixed or frequency agile operation.

For some RFID applications a maximum permitted power level of 500 mW will be sufficient. However situations will arise where to meet the needs of end users a higher power level is necessary. One way that this might be achieved while minimising the risk of interference to other SRDs is to permit different power levels in the different channels. An example of such scheme is shown in figure 1.

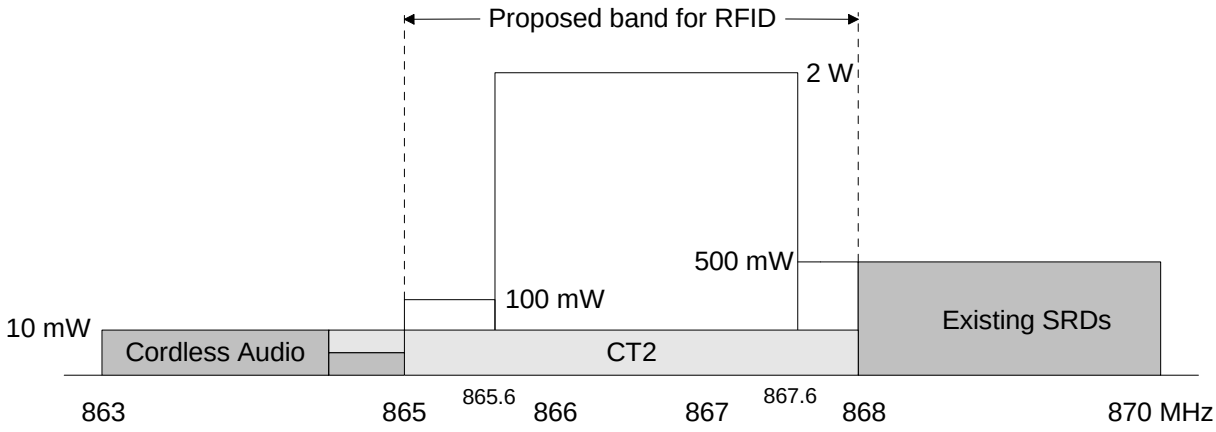



**Figure 1**

**Current regulations**

Technical and regulatory parameters are defined in the CEPT/ERC/REC 70-03 [1] in annex 1 (Generic applications) The existing UHF sub-bands do not permit sufficient bandwidth and power to operate RFID tags.

The new band plan extends the frequency range from 868 MHz to 870 MHz to 865 MHz to 870 MHz. This would allow the operation of a number of wideband channels for non-specific SRDs as well as RFID devices.

# 5 Main conclusions

The UHF system as described meets the performance requirements of the market and provides global interoperability of RFID systems.

Efficient use of the spectrum is assured by frequency agile technology avoiding or minimizing interference both to other co-channel systems and to users of adjacent bands.

Preliminary compatibility studies were conducted with positive results using RFID systems at 500 mW together with both cordless audio and radio modems. To implement the use of RFID systems at UHF new ETSI documentation will be necessary as well as amendment of the CEPT/ERC/REC 70-03 [1].

**Requested ERC actions**

- Compatibility evaluations and studies for services as defined under C1 and C2.
- Update of CEPT/ERC/REC 70-03 [1] annex 1.

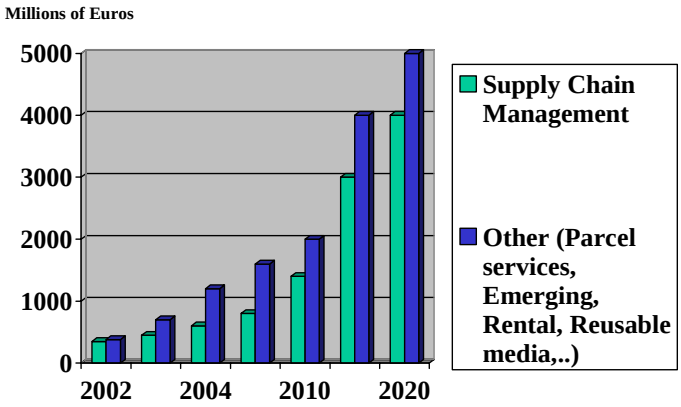
# Annex A:
# Detailed market information

## A.1 Range of applications

**Item Management**

| | |
|---|---|
| Pallet Management | Logistical Assets |
| Containers | Returnable Trade Items |
| Totes, Crates, Boxes | Truck Trailers |
| Paper Rolls | |

## A.2 Market size and value




Source: EAN International

**Figure A.1**

## A.3 Traffic evaluation

The traffic evaluation can be estimated from the number of systems, the average emitted power based on antenna patterns and the data rate as reflected by the bandwidth.

The power level will range from 100 mW to 2 W depending on the tag technology and the needs of each individual site. Battery assisted tags require lower power while batteryless tags generally need up to 2 W.

The ratio of reader to tags typically will vary from 1 : 500 to 1 : 5 000. Most readers will operate only on receipt of an external trigger.

# Annex B:
# Technical information

## B.1 Detailed technical description

The system operates in half duplex using adaptive frequency agile techniques with "listen before talk". For much of the time the reader will be in its "rest" state during which the reader will be powered up but will not transmit its carrier. On the approach of a tag the reader can receive an external trigger command, which will switch it to its "operational" state. This will initiate the idle mode during which the reader will transmit a succession of pulses. Each pulse comprises a wake-up command followed by a period of emission of continuous carrier. A pulse will have a duration of approximately 5 ms. As soon as a tag reaches the interrogation field, providing its "application identifier" matches the one emitted by the reader, it will transmit its response. The interrogator will then enter into a dialogue with the tag during which it may read data from the tag's memory or write to it additional information. In the event that multiple tags are present in the interrogation field, they will reply in accordance with an anti-collision algorithm.

The data transmitted by the interrogator is AM at 40 % depth of modulation at a data rate of 40 kBaud. The tag replies using AM modulated backscatter at 66 kBaud.

Details of the spectrum mask are shown in the figure below. Spurious emissions will be less than 250 nW in accordance with the limit in EN 300 220-1 [2].

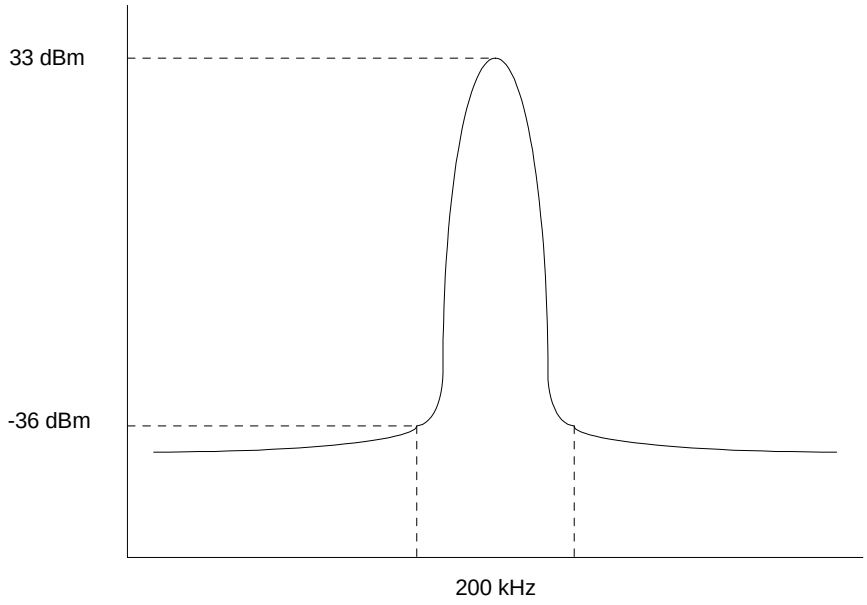



**Figure B.1**

## B.2 Technical justifications for spectrum

### B.2.1 Power

2 W power is preferred in order for ISO/IEC 18000-6 (see bibliography) and GTAG™ to achieve the necessary reading range of 2 m using batteryless tags. The power level and possible mitigation techniques such as duty cycle have to be determined after completion of compatibility studies.

### B.2.2 Frequency (See also spectrum requirements clause 4.2)

UHF has been chosen by GTAG™ as the best compromise frequency, because it offers the greatest read range for a given transmit level. (e.g. vs. 2,45 GHz) and suffers less from the problems of range reduction with water and reflections than at 2,45 GHz. Because of the proximity of Tags to products that may be aqueous or metallic, these are important considerations.

In addition an adequate allocation of bandwidth is necessary to permit the use of sufficient channels. This requirement is specified in the proposed Bandplan under clause 4.2.

## B.3 Information on current version of relevant ETSI standard

At the time of drafting of the present System Reference Document existing SRDs in the UHF band are covered by EN 300 220-1 [2]. Appropriate documentation will be necessary to handle the particular requirements of RFID systems (e.g. operation with 2 W).

# Annex C:
# Expected compatibility issues

## C.1 Coexistence studies

Studies will be necessary between RFID and other systems using the same band or adjacent bands:

- Tactical Radio Relay Link (TRRL) where or when applicable;
- CT2 systems and with other SRDs such as tele-alarm, telemetry, DSSS, FHSS and cordless audio devices in adjacent bands and within the defined sub-bands;
- Television (channel 69) and aeronautical in some countries (S5.323).

Practical initial tests (See document ETSI/ERM(01)SA47R1 for details of GTAG compatibility assessment,) show no detrimental interference above distances of 30 cm.

Theoretical data (see note): Class 1, Indoor = 5 m, Open Air = 26 m

(Blocking) (see note): Class 2, Indoor = 30 m, Open Air = 300 m

NOTE: Data provided by Felix Elsen, Philips (11 May 2001).

The practical tests were performed with product designed for the US market, but using different parameters (e.g. Operating frequency).

## C.2 Current ITU allocations

In Region 1: FIXED, MOBILE except aeronautical mobile.

## C.3 Sharing issues

The compatibility studies should take into account SRD services and applications mentioned in the Strategic Plan for the use of SRD applications within the band 862 MHz to 870 MHz as adopted by the WG FM including spread spectrum systems across the band 863 MHz to 870 MHz.

# Annex D:
# Item check list

1) Approval by TG28.
2) Review and Decision of System Reference Document ERM-RM_10(01)118R4 by ETSI TC ERM RM.
3) If accepted, Liaison Statement to SRD MG from ETSI TC ERM.
4) If accepted by SRD-MG, liaison statement to SE 24 to provide detailed compatibility studies.
5) Completion of compatibility studies.
6) Generate appropriate ETSI documentation.
7) Amend CEPT/ERC/REC 70-03 [1] annex 1.

# Annex E: Bibliography

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

ETSI ETR 028: "Radio Equipment and Systems (RES); Uncertainties in the measurement of mobile radio equipment characteristics".

ISO/IEC 18000-6: "Information Technology AIDC Techniques-RFID for Item Management Air Interface; Part 6: q Parameters for Air Interface Communications at UHF frequencies".

# History

| Document history | | |
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| V1.1.1 | April 2002 | Publication |
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