

**Electromagnetic compatibility  
and Radio spectrum Matters (ERM);  
Technical characteristics of  
Short Range Devices (SRD) and RFID in the UHF Band;  
System Reference Document for  
Radio Frequency Identification (RFID) and SRD equipment;  
Part 2: Additional spectrum requirements for UHF RFID,  
non-specific SRDs and specific SRDs**

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Pursuant to the ETSI IPR Policy, no investigation, including IPR searches, has been carried out by ETSI. No guarantee can be given as to the existence of other IPRs not referenced in ETSI SR 000 314 (or the updates on the ETSI Web server) which are, or may be, or may become, essential to the present document.

## Foreword

This Technical Report (TR) has been produced by ETSI Technical Committee Electromagnetic compatibility and Radio spectrum Matters (ERM).

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 Postal and Telecommunications Administrations (CEPT).

The present document is part 2 of a multi-part deliverable covering RFID and SRD applications in the UHF range as identified below:

**Part 1:** "RFID equipment operating in the range from 865 MHz to 868 MHz";

**Part 2:** " **Additional spectrum requirements for UHF RFID, non-specific SRDs and specific SRDs**".

## Introduction

The present document requests additional spectrum for UHF RFID, non-specific SRDs and specific SRDs. The additional spectrum is considered necessary because of the rapid growth rate of all these devices and their use in mass market applications. Furthermore the operation of these equipment in globally harmonized frequency bands is highly desirable, especially in view of the forthcoming SRD studies in the ITU-R as a consequence of the Radio Assembly 07 resolution [i.14] and the WRC 07 Resolution [i.15]. This could potentially lead to the global harmonization of spectrum for some of these applications.

The present document is a revision of the original proposal that includes an update to inform the ECC.

## Status of the pre-approval draft

The present document is submitted to TG34 and TG28 for approval and intended for approval by TC\_ERM #40.

Target version	Pre-approval date version (see note)			Date	Description
	A	s	m		
V1.2.1		0.0.1		? February 2010	1 <sup>st</sup> for approval by TG34
V1.2.1		0.0.2		26 February 2010	Approved by TG34 for submission to ERM

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# 1 Scope

The present document applies to UHF RFID, non-specific SRDs such as Home and Building Automation, Telemetry, Data Transmission and specific SRDs such as Metering (water and energy), Alarms, Automotive applications.

The present document describes the development of the RFID and SRDs industries and requests a study into additional frequency designations in the UHF frequency band to meet the medium and long term market requirements of these equipment.

The present document is intended to include all necessary information required by the Electronic Communications Committee (ECC) under the MoU between ETSI and the ECC.

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# 2 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 reference document (including any amendments) applies.

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 necessary for the application of the present document.

Not applicable.

## 2.2 Informative references

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] Commission Decision of 23 November 2006 on harmonization of the radio spectrum for radio frequency identification (RFID) devices operating in the ultra high frequency (UHF) band.

[i.2] "The RFID Revolution: Your voice on the Challenges, Opportunities and Threats".

NOTE: Available at [http://ec.europa.eu/information\\_society/policy/rfid/documents/rfidswp\\_en.pdf](http://ec.europa.eu/information_society/policy/rfid/documents/rfidswp_en.pdf).

[i.3] BRIDGE Building Radio frequency Identification solutions for the Global Environment, European passive RFID Market Sizing 2007 - 2022, GS1.

[i.4] ERC Recommendation 70-03: "Relating to the use of short range devices (SRD)".

NOTE: Available at [http://www.erodocdb.dk/doks/implement\\_doc\\_adm.aspx?docid=1622](http://www.erodocdb.dk/doks/implement_doc_adm.aspx?docid=1622).

[i.5] IDTechEx: "Boom in RFID will be reflected in Europe's Leading Conference".

NOTE: Available at <http://www.idtechex.com/>.

[i.6] Wireless Technology Propels Expansion of European Residential Security Market.

NOTE: Available at <http://www.frost.com/prod/servlet/press-release.pag?Src=RSS&docid=95217860>.

- [i.7] ETSI EN 302 208 (all parts) (V1.2.1): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Radio Frequency Identification Equipment operating in the band 865 MHz to 868 MHz with power levels up to 2 W".
- [i.8] ETSI EN 300 220 (all parts) (V2.1.2): "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".
- [i.9] EC: "Towards an RFID Policy for Europe".
- NOTE: Available at [http://www.rfidconsultation.eu/docs/ficheiros/RFID\\_Workshop\\_Reports\\_Final.pdf](http://www.rfidconsultation.eu/docs/ficheiros/RFID_Workshop_Reports_Final.pdf).
- [i.10] ISO/IEC 18000-6 (1st edition; 15 August 2004): "Information technology - Radio frequency identification for item management - Part 6: Parameters for air interface communications at 860 MHz to 960 MHz".
- [i.11] ISO/IEC 18000-6 (2004) AMD1 (E) (19 June 2006): "Information Technology - Radio frequency identification for item management - Part 6: Parameters for air interface communications at 860 MHz to 960 MHz, Amendment 1: Extension with Type C and update of Types A and B".
- [i.12] CEPT Report 14 (July 2006): "Develop a strategy to improve the effectiveness and flexibility of spectrum availability for Short Range Devices (SRDs) in response to the EU Commission mandate".
- [i.13] Void.
- [i.14] ITU-R Radio Assembly 2007: Resolution 953 Studies to achieve further harmonization for short-range radiocommunication devices (SRDs).
- [i.15] ITU-R World Radio Conference 2007 Resolution [COM6/4] (WRC-07) Protection of radiocommunication services from emissions by short-range radio devices.
- [i.16] Kyoto Protocol to the United Nations framework convention on climate change (United Nations 1998).
- [i.17] Directive 2002/91/EC of the European Parliament and of the Council of 16 December 2002 on the energy performance of buildings.
- [i.18] Directive 2006/32/EC of the European Parliament and of the Council of 5 April 2006 on energy end-use efficiency and energy services and repealing Council Directive 93/76/EEC.
- [i.19] ECC Report 11: "Strategic plans for the future use of the frequency bands 862-870 MHz and 2400-2483.5 MHz for short range devices".
- [i.20] Council Directive 89/106/EEC of 21 December 1988 on the approximation of laws, regulations and administrative provisions of the Member States relating to construction products.
- [i.21] CEN EN 14604:2005: "Smoke alarm devices".
- [i.22] ECC Report 34: "Compatibility between narrow band digital PMR/PAMR and tactical radio relay in the 900 MHz band, Cavtat, May 2003".
- [i.23] ECC Report 38: "Technical impact of introducing CDMA-PAMR on the UIC DMO & GSM-R radio systems in the 900 MHz band, Granada, February 2004".
- [i.24] ECC Report 40: "Adjacent band compatibility between CDMA-PAMR mobile services and short range devices below 870 MHz", Granada, February 2004.
- [i.25] ECC Report 41: "Adjacent band compatibility between GSM and CDMA-PAMR at 915 MHz", Granada, February 2004.
- [i.26] ECC Report 58: "Compatibility between TETRA Release 2 TAPS and tactical radio relays in the 870-876 AND 915-921 MHz bands", Stockholm, October 2004.
- [i.27] ECC Report 96: "Compatibility between UMTS 900/1800 and systems operating in adjacent bands", Krakow, March 2007.

- [i.28] ECC Report 37: "Compatibility of planned SRD applications with currently existing radiocommunication applications in the frequency band 863 - 870 MHz", Granada, February 2004.
- [i.29] CEN EN 54-25:2008: "Fire detection and fire alarm systems - Part 25: Components using radio links and system requirements".
- [i.30] ETSI-ERM-TG34: 17-07-Analysis-of-RFID-Questionnaire.
- [i.31] Commission Decision amending Decision 2006/771/EC on the harmonization of the radio spectrum use by short range devices.
- NOTE: Available at <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:151:0049:0054:EN:PDF>.
- [i.32] ACEA: "Vehicles in use".
- NOTE: Available at [http://www.acea.be/index.php/news/news\\_detail/vehicles\\_in\\_use/](http://www.acea.be/index.php/news/news_detail/vehicles_in_use/).
- [i.33] Study on legal, economic & technical aspects of "Collective Use of Spectrum" in the European Community (November 2006) by order of EU Commission.
- [i.34] ECC Report 5: "Adjacent band compatibility between GSM and TETRA mobile services at 915 MHz".
- [i.35] CEN EN 15232:2007: "Energy performance of buildings - Impact of Building Automation, Controls and Building Management".
- [i.36] Directive 98/34/EC of the European Parliament and of the Council of 22 June 1998 laying down a procedure for the provision of information in the field of technical standards and regulations.
- [i.37] Directive 98/48/EC of the European Parliament and of the Council of 20 July 1998 amending Directive 98/34/EC laying down a procedure for the provision of information in the field of technical standards and regulations.
- [i.38] ETSI TR 102 627: "Electromagnetic compatibility and Radio spectrum Matters (ERM); System Reference Document; Land Mobile Service; Additional spectrum requirements for PMR/PAMR systems operated by railway companies (GSM-R)".
- [i.39] Federal Network Agency, Germany, Measurement Report: "Feasibility Tests between E-GSM-R and UHF RFID" at Kolberg, Germany, 25th to 26th June 2009.
- [i.40] Federal Network Agency, Germany, Measurement Report: "Feasibility Tests between E-GSM-R and Low Duty Cycle SRD" at Kolberg, Germany, 19th to 20th August 2009.
- [i.41] ETSI STF Methods, parameters and test procedures for cognitive interference mitigation for use by UHF RFID using Detect-And-Avoid (DAA) or other similar techniques.
- [i.42] CEPT/ECC Decision (02)05 amended: "ECC Decision of 5 July 2002 on the designation and availability of frequency bands for railway purposes in the 876-880 MHz and 921-925 MHz bands amended 26 June 2009".
- [i.43] CEPT/ECC Decision (04)06 amended: "ECC Decision of 19 March 2004 on the availability of frequency bands for the introduction of Wide Band Digital Land Mobile PMR/PAMR in the 400 MHz and 800/900 MHz bands amended Annex 27-06-08 / amended Decision 26 06 09".
- [i.44] 046SE(09)Annex18: "Liaison Statement to WGFM on the extension band for GSM-R".
- [i.45] ERC DEC (01)09: "ERC Decision of 12 March 2001 on harmonised frequencies, technical characteristics and exemption from individual licensing of Short Range Devices used for Alarms operating in the frequency bands 868.60 - 868.7 MHz, 869.25 - 869.3 MHz, 869.65 - 869.7 MHz".
- [i.46] ERC DEC (97)06: "ERC Decision of 30 June 1997 on the harmonised frequency band to be designated for Social Alarm Systems".

NOTE: Withdrawn under ERC DEC (08)02.



- [i.47] ECC DEC (05)02: "ECC Decision of 18 March 2005 on the use of the Frequency Band 169.4 – 169.8125 MHz".
- [i.48] ETSI TR 102 649-2 (V1.1.1): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Technical characteristics of Short Range Devices (SRD) and RFID in the UHF Band; System Reference Document for Radio Frequency Identification (RFID) and SRD equipment; Part 2: Additional spectrum requirements for UHF RFID, non-specific SRDs and specific SRDs".

## 3 Definitions, symbols and abbreviations

### 3.1 Definitions

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

**alarms:** fixed or portable device that uses radio communication for indicating an alert condition at a distant location

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

**duty cycle:** for the purposes of the ERC Recommendation 70-03 [i.4], the duty cycle is defined as the ratio, expressed as a percentage, of the maximum transmitter "on" time on one carrier frequency, relative to a one hour period

NOTE 1: For frequency agile devices the duty cycle limit applies to the total transmission.

NOTE 2: For specific applications with very low duty cycles and very short periods of transmissions, the definition of duty cycle should be subject to study.

**Home and Building Automation:** Business and Residential control and system management by radio communication

**listen before talk:** action taken by a device to detect an unoccupied channel prior to transmitting

NOTE: Also known as "listen before transmit".

**metering:** metering (water and energy) by radio communication

**Short Range Devices (SRDs):** radio devices which provide either unidirectional or bi-directional communication and which have low capability of causing interference to other radio equipment

NOTE: SRDs use either integral, dedicated or external antennas and all modes of modulation can be permitted subject to relevant standards. SRDs are normally "license exempt".

**specific SRDs:** SRDs that are used in specific applications

NOTE: E.g. Applications of ERC Recommendation 70-03 [i.4], annexes 2 to 13.

**tag, transponder:** device that responds to an interrogation signal

**Tari:** reference time interval for a data-0 in Interrogator-to-Tag signalling

NOTE: The mnemonic "Tari" derives from the ISO/IEC 18000-6 (part A) specification [i.10], in which Tari is an abbreviation for Type A Reference Interval.

**telegram:** data transmitted during one duty cycle

**tertiary sector (of industry):** the service sector, or the service industry

NOTE: This is one of the three main industrial categories of a developed economy.

## 3.2 Symbols

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

E	Electrical field strength
f	frequency
f <sub>c</sub>	centre frequency
P	Power
d	distance
t	time
λ	Wavelength

## 3.3 Abbreviations

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

ACEA            European Automobile Manufacturers' Association

NOTE:    See <http://www.acea.be/>.

AFA	Adaptive Frequency Agility
BRIDGE	Building Radio frequency Identification solutions for the Global Environment
BS	Base Station
CEPT	Conference of Post and Telecommunications Administrations
DAA	Detect-And-Avoid
DC	Duty Cycle
DSSS	Direct Sequence Spread Spectrum
e.i.r.p.	equivalent isotropic radiated power
e.r.p.	effective radiated power
EC	European Commission
ECC	Electronic Communications Committee
ER-GSM	Extended Railways GSM
ERM	Electromagnetic compatibility and Radio spectrum Matters
EU	European Union
EVVE	The Association for Energy Cost Allocation
FHSS	Frequency Hopping Spread Spectrum
FM	Frequency Management
FSK	Frequency Shift Keying
GSM	Global System for Mobile Communications
GSM-R	GSM-Railway
HSD	Home Smoke Detector
LBT	Listen Before Talk
MS	Mobile Station
NRE	Non-Recurring Expenditure
OBW	Occupied BandWidth
PAMR	Public Access Mobile Radio
PIR	Passive InfraRed
PLL	Phase Locked Loop
PMR	Private Mobile Radio
RF	Radio Frequency
RFID	Radio Frequency Identification
RKE	Remote Keyless Entry
RSCOM	Radio Spectrum Committee
Rx	Receiver
SME	Small and Medium Enterprises
SRD	Short Range Device
TPMS	Tyre Pressure Monitor Systems
UHF	Ultra High Frequency
UMTS	Universal Mobile Telecommunications System
WG	Working Group

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## 4 Comments on the System Reference Document

TC ERM has received a liaison statement from TC TETRA stating that they have no plans to use the dual band 870 MHz to 876 MHz and 915 MHz to 921 MHz. A copy of this letter is attached at annex D. It should be noted that in 2009 3GPP GERAN withdrew the T-GSM 900 specifications for the use of this frequency band due to the lack of implementation.

### 4.1 Recent and ongoing activities

In the spring of 2009 TC GSM-R prepared an SRDoc [i.38] which was submitted to ECC. This document [i.38] stated that in some European states the railways had identified an operational need for additional capacity. To meet this demand GSM-R requested an extension of their present band to include the frequency ranges 873 MHz to 876 MHz and 918 MHz to 921 MHz. WGFM considered this request and indicated that it was likely to be acceptable.

The frequencies requested by GSM-R are the same as part of the additional bands proposed in this SRDoc for use by SRDs and RFID. In order to determine if it would be possible for SRDs and RFID to share the bands with GSM-R, it was decided to undertake some feasibility tests. These were carried out in the presence of a representative from the railways at the BNetzA test laboratory in Kolberg. Reports on these tests are available in ETSI ERM [i.39] and [i.40]. The reports conclude that sharing of the bands by SRDs and RFID with GSM-R should be feasible. However due to the higher transmit powers proposed for RFID, it was considered that suitable mitigation techniques would be necessary by RFID to avoid unacceptable interference to ER-GSM.

Subsequently the reports on the feasibility tests were considered within ETSI. It was decided to initiate an STF with the objective of proposing acceptable methods of mitigation for RFID. This activity will be undertaken jointly by members of TC RT ER-GSM and ERM\_TG34. A TOR for the STF under the title "Methods, parameters and test procedures for cognitive interference mitigation for use by UHF RFID using Detect-And-Avoid (DAA) or other similar techniques" [i.41] was prepared and approved by the ETSI Board. Work on the STF will commence in February 2010 and will take place in two phases. Phase 1 will culminate in June with a draft TS, which will recommend a suitable method of mitigation. Phase 2 will involve the development of a test-bed in order to demonstrate practically that the proposed method of mitigation performs as intended. The results of phase 2 will be documented in a TR, which should be published at the end of 2010.

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## 5 Executive summary

The present document requests the designation of additional spectrum in the UHF spectrum for RFID and SRDs. These devices are already installed in large numbers across a wide range of applications within Europe and their use is expected to grow rapidly over the next 10 years. It is anticipated that the current designations of spectrum for RFID and SRDs will be inadequate to meet their future needs. The present document provides independent marketing data that predicts considerable market growth in RFID and SRDs. ECC is requested to undertake a compatibility study in order that additional spectrum may be made available.

The present document identifies two unused frequency bands that could be designated for use by RFID and SRDs. It is believed that for technical reasons these bands cannot be used by the mobile industry (see clause 6.2). It is therefore proposed that the bands are re-designated so that they can be put to productive use.

This proposal provides the following justification for the designation of additional spectrum for RFID and SRDs, as already recognized by the CEPT Report 14 [i.12] (see clause 9.7.3.1) and the Collective Spectrum Use report [i.33], both mandated by the European Commission:

- It is predicted that the use of RFID in Europe will grow dramatically over the next 15 years. As the commercial benefits of RFID become more widely recognized, the technology will be adopted by many new industries. Some of these applications will require improvements to existing RFID performance. Typical examples include greater reading range, improved reading performance, faster data rates and the use of sensors (e.g. temperature, pressure, etc.) within tags. These requirements can only be met by the provision of additional spectrum. A detailed market analysis is given in annex A.

- The SRD industry has expanded considerably over recent years and has now developed into a number of different industrial sectors. These include metering, automotive applications, alarms, and in wider terms, non-specific SRDs such as home and building automation, telemetry, data transmissions, etc. It is anticipated that the present trend in diversification and expansion will continue. An indication of the potential size of the market for SRDs is provided in annex A. Based on these predictions of market growth, it is very evident that additional spectrum will be necessary. This point was already identified in November 2006 in CEPT Report 14 [i.12] in response to a mandate from the EU Commission to develop a strategy to improve the effectiveness and flexibility of spectrum designation for SRDs. The Report recommended that:
  - (i) "That CEPT ensures that only the minimum regulations are specified in Recommendation 70-03 and, where appropriate, the application-specific constraints to spectrum use are removed".
  - (ii) "New bands should preferably be extensions of SRD bands or close to them".
  - (iii) "Introduction of LBT and/or AFA in existing SRD bands is a first priority. However, any benefit from the introduction of LBT and/or AFA may be short lived if the anticipated growth in SRDs occurs. Therefore the identification of new spectrum for SRDs employing these techniques is a second priority".
- The present document has identified two frequency bands, unused by the PMR industry for 15 years. These bands are at 870 MHz to 876 MHz and at 915 MHz to 921 MHz. These could be designated for use by RFID and SRDs. For the reasons given in clause 6.2.1, it is not possible for the mobile industry to operate in these bands. ECC is therefore requested to undertake a compatibility study to determine how these bands could be designated for use by RFID and SRDs.
- As a result of their joint discussions, ETSI\_ERM TG28 and TG34 concluded that it would be desirable to separate the high power transmissions of RFID from the low power levels associated with SRDs. The present document therefore proposes that the band 870 MHz to 876 MHz is designated for use by SRDs at less than 100 mW and the band 915 MHz to 921 MHz is designated for high power devices such as RFID (see clause 6.2.2). An important requirement from the industry is that the new SRD bands should be an extension of the present SRD bands or close to them.
- To satisfy the perceived future market requirements for RFID, it is proposed that interrogators will operate in the band 915 MHz to 921 MHz at power levels of up to 4 W e.r.p. in four channels of 400 kHz each. The remainder of the band will be used for the low level response from the tags. This will increase reading performance and potentially permit data rates that are four times faster than those currently possible. Details of the proposed channel plan are provided in annex A.

Designation of the band 870 MHz to 876 MHz for use by SRDs will satisfy the foreseeable market requirements of the industry. For technical reasons it is proposed to divide the band into two segments. One of these segments covers devices which use duty cycle up to 1 % or LBT with AFA (or equivalent techniques). The other segment is aimed at SRDs that transmit intermittent very short bursts of power and rely on duty cycle for mitigation. The proposed band plan is shown at figure 3. The subdivision of the band into two segments (i.e. non-specific SRDs and specific SRDs) without any further segmentation in each sub-band, fully complies with the spectrum policy for SRDs proposed by the EU Commission. This policy was supported by Member States at the Radio Spectrum Committee meeting of 4-5 December 2006 (see Report 14 [i.12], clause 5.2 for details). This also complies with the key first recommendation of the CEPT Report 14 [i.12] in response to a mandate from the EU Commission to develop a strategy to improve the effectiveness and flexibility of spectrum designation for SRDs (see clause 5.2 of the present document for details). *"That CEPT ensures that only the minimum regulations are specified in Recommendation 70-03 and, where appropriate, the application-specific constraints to spectrum use are removed"*.

## 5.1 Market information

### 5.1.1 RFID

Market information that supports the predicted rapid growth of RFID is provided at clause A.1 of the present document. In addition reference is made to a number of independent market studies such as given in clause A.1.1.

### 5.1.2 Non-specific SRDs

Market information for non-specific SRDs is provided in clause A.2.

### 5.1.3 Specific SRDs

Market information for specific SRDs is provided in clause A.3.

The market information for non-specific SRDs and specific SRDs shows more rapid growth than the conclusions given in 2006 CEPT Report 14 [i.12] called "*Short Range Device Industry: Market and Technology Trends*". The same applies to similar market studies and investigations contained in the Report on "Collective Spectrum Use" [i.33]. Both Reports are in response to a mandate from the European Commission.

Details are given in clause 7.2.2.2.

## 5.2 Technical issues

### 5.2.1 RFID

Clause B.1 shows the channel plan and spectrum mask details for RFID in the proposed band of 915 MHz to 921 MHz.

### 5.2.2 SRDs

Clauses B.2 and B.3 show the band plan and technical details for non-specific and specific SRDs in the proposed band 870 MHz to 876 MHz. Additional technical information is provided for each of the industrial sectors.

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## 6 Future requirements

The common view of industry, the European Commission [i.33] and CEPT [i.12] is that the 865 MHz to 868 MHz band will be sufficient to cover the immediate spectral needs of UHF RFID. However a lack of spectrum in the UHF frequency range will arise. Unless addressed, this will seriously restrict the forecasted exponential market growth of the industry.

The situation for non-specific and specific SRDs is the same because of their rapidly increasing density and their expansion into a wider range of applications. In particular this is illustrated by the new generation of SRDs in Home and Building automation, metering, alarms and automotive.

A more detailed description of the SRD applications and the justification for additional spectrum is given in clauses A.2 and A.3.

NOTE: The military use of the bands under consideration should be assessed by ECC during consideration of the present document.

### 6.1 RFID applications

RFIDs are used in item management, logistics and in a wide range of other applications. Details are provided in clause A.1.

Many of these applications require reading ranges of at least 2 meters, and in certain logistics applications ranges from 5 meters to 10 meters. These ranges cannot be provided by alternative technologies and at any other frequency due to the regulatory constraints.

Additional spectrum needs are based on increased RFID usage densities, greater operating distances, and higher data speeds that will permit applications where large numbers of RFID tags are read reliably and quickly.