ETSI TR 102 400 V1.2.1 (2006-07)

Technical Report

Electromagnetic compatibility and Radio spectrum Matters (ERM); Short Range Devices (SRD); Intelligent Transport Systems (ITS); Road Traffic and Transport Telematics (RTTT); Technical characteristics for communications equipment in the frequency band from 63 GHz to 64 GHz; System Reference Document

Reference
RTR/ERM-RM-050

Keywords
CALM, EHF, radio, RTTT, short range, SRD, SRDoc

ETSI

650 Route des Lucioles
F-06921 Sophia Antipolis Cedex - FRANCE

Tel.: +33 4 92 94 42 00 Fax: +33 4 93 65 47 16

Siret N° 348 623 562 00017 - NAF 742 C
Association à but non lucratif enregistrée à la
Sous-Préfecture de Grasse (06) N° 7803/88

Contents

Intellectual Property Rights

IPRs essential or potentially essential to the present document may have been declared to ETSI. The information pertaining to these essential IPRs, if any, is publicly available for **ETSI members and non-members**, and can be found in ETSI SR 000 314: *"Intellectual Property Rights (IPRs); Essential, or potentially Essential, IPRs notified to ETSI in respect of ETSI standards"*, which is available from the ETSI Secretariat. Latest updates are available on the ETSI Web server (http://webapp.etsi.org/IPR/home.asp).

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).

Introduction

The present document includes necessary information to support the co-operation under the MoU between ETSI and the Electronic Communications Committee (ECC) of the European Conference of Post and Telecommunications Administrations (CEPT) for amending the ERC Recommendation 70-03 [1].

1 Scope

The present document defines the requirements for radio frequency usage for RTTT and ITS equipment operating in the 63 GHz to 64 GHz frequency range.

It includes necessary information to support the co-operation between ETSI and the Electronic Communications Committee (ECC) of the European Conference of Post and Telecommunications Administrations (CEPT), including:

- market information (annex A);
- technical information (annex B);
- expected compatibility issues (annex C).

2 References

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

[1] CEPT/ERC Recommendation 70-03: "Relating to the use of Short Range Devices (SRD)", annex 5.

[2] CEPT/ECC/DEC/(02)01: "Frequency bands to be designated for the co-ordinated introduction of Road Transport and Traffic Telematic Systems".

[3] ITU-R Recommendation SM.1538-1: "Technical and operating parameters and spectrum requirements for short-range radiocommunication devices".

[4] IEEE 802.11a: "Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) specifications - Amendment 1: High-speed Physical Layer in the 5 GHz Band." Adopted by the ISO/IEC and redesignated as ISO/IEC 8802-11:1999/Amd 1:2000(E).

[5] CEPT/ERC Report 3: "Harmonization of frequency bands to be designated for road transport information systems".

[6] CEPT/ERC Report 25: "The European Table of Frequency Allocations and Utilizations Covering the Frequency Range 9 KHz to 275 GHz", Lisbon January 2002 - Dublin 2003 - Turkey 2004.

[7] ITU Radio Regulations (2004).

[8] Council Recommendation of 12 July 1999 on the limitation of exposure of the general public to electromagnetic fields 0 Hz to 300 GHz (1999/519/EC).

[9] CENELEC EN 50392: "Generic standard to demonstrate the compliance of electronic and electrical apparatus with the basic restrictions related to human exposure to electromagnetic fields (10 MHz - 300 GHz)".

[10] FCC 47 CFR Ch. I, 15.255: "Operation within the band 59.0 to 64.0 GHz".

[11] ISO/CD 21217: "Communications, Air Interface, Long and Medium Range (CALM) - Architecture".

3 Definitions, symbols and abbreviations

3.1 Definitions

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

EIRP: product of the power supplied to the antenna and the maximum antenna gain relative to an isotropic radiator (absolute or isotropic gain)

roadside unit: roadside unit includes localized transmitters or receivers or both functions integrated into one unit

roadside-to-vehicle communications: also includes vehicle-to roadside communications

roadside: includes:

- single RSUs operating in a stand-alone fashion; or
- a group of RSUs connected together by an appropriate infrastructure, which may include an information network; or
- a single RSU connected to an information network.

3.2 Symbols

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

Bn	billion (=10^9)
dB	decibel
dBm	dB relative to 1 milliwatt
dBW	dB relative to 1 Watt
GHz	Gigahertz
m	metre
s	second

3.3 Abbreviations

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

AFC	Automatic Fee Collection
BPSK	Binary Phase-Shift Keyed
CALM	Communications Air interface Long and Medium
CEPT	European Conference of Post and Telecommunications Administrations
DPSK	Differential Phase Shift Keyed
EBG	Electronic Band-Gap
ECC	Electronic Communications Committee
EIRP	Equivalent Isotropically Radiated Power
ERM	Electromagnetic compatibility and Radio spectrum Matters
FCC	Federal Communications Commission
FSK	Frequency Shift Keyed
IEEE	Institution of Electrical and Electronic Engineers
IF	Intermediate Frequency
ISM	Industrial, Scientific and Medical
ISO	International Standards Organization
ISS	Inter-Satellite Service
ITS	Intelligent Transport Systems
IVC	Inter-Vehicle Communications
LAN	Local Area Network
LEO	Low Earth Orbit
MAC	Medium Access Control

MoU	Memorandum of Understanding
OFDM	Orthogonal Frequency Division Multiplex
PHY	PHYsical layer
QAM	Quadrature Amplitude Modulation
QPSK	Quadrature Phase Shift Keyed
RF	Radio Frequency
RM	Radio Matters
RSU	Road-Side Unit
RTTT	Road Transport and Traffic Telematics
RVC	Roadside-to-Vehicle Communications
Rx	Receiver
SNR	Signal-to-Noise Ratio
SRD	Short Range Device
TDD	Time Division Duplexing
Tx	Transmitter
WG	Working Group

4 Executive summary

The present document takes forward previous CEPT/ECC Decisions and Recommendations relating to millimetric communications for **Transport Telematics** applications, and makes the case for the use of the 63 GHz to 64 GHz band for all applications that are generally included in this description. The proposals are backed by the work currently being done by a range of companies who have an integrated plan to realize a "next generation road vehicle communication" system in the immediate future.

The present document's objectives are to:

a) demonstrate that the need for high data rate communications in the millimetric band is a real and growing one;

b) provide justification for the continued designation in Europe of 63 GHz to 64 GHz;

c) illustrate the advantages of the use of the 63 GHz to 64 GHz band, in respect of:

   i) the ability to form and control beam patterns resulting from the small wavelength and thus viable size of antennas, the advantage this brings in respect of control of exposure of radiations to users and other humans and animals, and in respect of channel optimization, and in respect of geographic re-use of bandwidth, and in respect of certainty of delivery of (and elimination of false delivery) of data to intended users;

   ii) the advantages resulting from oxygen in respect of geographic re-use of bandwidth, and in respect of compatibility issues with other services, and the particular aspects of the Transport Telematics application that suit it to this band.

d) illustrate how safety, management, regulatory and commercial applications can co-exist "symbiotically", and be combined to deliver ALL applications more readily (in respect of timescales and financially) and to show the enormous economic benefit that this approach will bring;

e) describe the technical aspects of the proposed usage and the items requiring standardization.

4.1 Status of the system reference document

ERM-RM#32 created a new work item for TR 102 400 (SRDoc for ITS/RTTT in 63 GHz to 64 GHz). The present document is the result of this decision, and updates and replaces all previous work and documents regarding ITS RTTT in 63 GHz to 64 GHz.

Version 1.2.1_1.1.2 was created and agreed at the ERM TG37#10 meeting; version 1.2.1_1.1.5 has taken account of subsequent comments from ETSI members and was also reviewed and finally adopted by ERM RM#32. The present document was forwarded to WG FM for consideration. After incorporating editorial & minor amendments considered to be necessary in TG37, the present version 1.2.1_1.1.6 was forwarded to ERM and approved for publication at ERM#28, Paris, 13^{th}-17^{th} March 2006. In addition, this version has been submitted for information to ITU-R WP 8A.

4.2 Market information

This information is provided in annex A.

4.3 Technical system description

This information is provided in annex B.

5 Current regulations

The need for RTTT data links and a suitable frequency assignment has been recognized for several years. As a result of some EC-funded work in the early 1990's which investigated frequency and design options, CEPT recommended the band 63 GHz to 64 GHz for future inter-vehicle and (in a later amendment) roadside-to-vehicle communications.

The current regulation permitting RTTT devices in the frequency band from 63 GHz to 64 GHz is found in CEPT/ERC Recommendation 70-03 [1], annex 5 and is shown in table 1.

Table 1: Current regulation in annex 5 of CEPT/ERC Recommendation 70-03 [1] for the 63 GHz to 64 GHz band

Frequency Band	Power	Duty cycle	Channel spacing	ERC Decision	Notes
63 GHz to 64 GHz	--	--	No spacing	ECC DEC(02)01 [2]	Vehicle-to-vehicle and roadside-to-vehicle systems Power level to be determined

ERC Report 3 [5] envisaged an EIRP of 3 dBW to 16 dBW for communication ranges of up to 300 m, with antenna gains in the range 10 dBi to 30 dBi.

In addition, ITU-R Recommendation SM.1538-1 [3] provides information on the technical and operating parameters and spectrum requirements for short range radiocommunication devices.

In some countries, the band 63 GHz to 64 GHz is included in a wider range (e.g. 59 GHz to 64 GHz) for which no specific uses have been specified, and which is subject to a local power restriction. ITU-R Recommendation SM.1538-1 [3] contains further details.

The FCC [10] currently has a limit for the band 59 GHz to 64 GHz at a distance of 3 m from the transmitter of 9μW/cm^2 (mean) and 18μW/cm^2 (peak), along with a maximum transmitted power of 500 mW. The maximum transmitted power corresponds to a radiated bandwidth of 100 MHz and greater; it is reduced pro-rata for emissions having a bandwidth of less than 100 MHz.

6 Proposed regulations

It is proposed that CEPT adopt power levels for the 63 GHz to 64 GHz band as shown in table 2 and include these in annex 5 of CEPT/ERC Recommendation 70-03 [1].

Table 2: Proposed regulation for the 63 GHz to 64 GHz band

Frequency Band	Power	Duty cycle	Channel spacing	ERC Decision	Notes
63 GHz to 64 GHz	40 dBm EIRP maximum mean power 43 dBm EIRP maximum peak power 27dBm maximum peak conducted power	No restriction	No spacing	ECC DEC(02)01 [2]	Vehicle-to-vehicle and road-to-vehicle systems Measured over any continuous period of 53 seconds. The maximum peak transmitted power is for an emission bandwidth of greater than 100 MHz. It is reduced pro-rata for an emission bandwidth less than 100 MHz

In addition, it is proposed that the title of annex 5 of CEPT/ERC Recommendation 70-03 [1] (currently "Road Transport and Traffic Telematics (RTTT)") and its scope be changed to include the term "Intelligent Transport Systems (ITS)".

Further information and justification on the need to have the set of parameters as shown in table 2 is given in clause B.2.1.

7 Main conclusions

A fast and versatile ITS communication system is needed to support the large number of RTTT and other applications (please see clause A.1.2) that have been identified. Systems are now being developed in support of this, making use of several bearer frequencies, including millimetre wave.

The ISO standards group TC204 WG16.1 has prepared and successfully balloted a specification (ISO/CD 21217) [11] for an architecture which will link applications to an appropriate bearer or bearers, depending on what each has to offer at a given time in a given situation. This will shortly become a full ISO /IEC Standard. It is recognized that all bearers cannot support all applications, and that there will be circumstances which favour one over another.

Millimetric systems in the 63 GHz to 64 GHz part of the spectrum can offer communications with a high data rate, typical ranges up to 1 km, a low reuse distance and minimal interference from and to other users, together with versatile frequency planning because of the available bandwidth. In addition, they can offer a method of obtaining redundancy when used with other systems for more safety-critical applications.

Prototypes became available in November 2005, and specialized short range demonstrators are expected in the near future.

8 Expected ECC actions

ETSI requests ECC to consider the present document, which includes necessary information to support the co-operation under the MoU between ETSI and the Electronic Communications Committee (ECC) of the European Conference of Post and Telecommunications Administrations (CEPT) for amending the CEPT/ERC Recommendation 70-03 [1].

ETSI requests that the ECC consider adopting the power levels in table 2 for inclusion in CEPT/ERC Recommendation 70-03 [1], annex 5 and also consider changing the title and scope of that annex to include the term "Intelligent Transport Systems (ITS)".

Annex A: Market information

A.1 Applications

A.1.1 Summary of required connectivity and examples of application types

The connectivity required by the application types can be summarized as follows:

- Inter-vehicle:
  - Vehicle cluster covering several lanes (e.g. lane management, overtaking assist, police instructions to vehicle in-front/behind).
  - Linear (e.g. convoy control).
  - Vehicle cluster including opposite direction (e.g. warnings to vehicle in opposite direction of travel, accident and event warning propagating backward).
- Vehicle to roadside (and roadside to vehicle):
  - One vehicle to beacon (e.g. alerts from private vehicles to highway control on accident, conditions).
  - Beacon to one vehicle (e.g. highway and traffic management and tolling).
  - Beacon to many vehicles (e.g. broadcast, safety, weather and traffic status messaging, disaster and emergency warning and control).
  - Beacon to selected vehicles (multicast, download of maps and route guidance).
- Safety, weather and traffic status messaging. It should be understood that all links are intended as bi-directional, both at an application level, and for Forward Error Correction and data block resend requests. Also, each message type can be present multiply in clusters of vehicles, with Medium Access Control (MAC).

A.1.2 Examples of applications

Lists of applications for IVC and RVC have been investigated by various projects and groups, and the number of applications is very high, typically 100. Some examples of applications are:

Parking Payment	Probe data collection
Access control (car and truck)	Toll collection
Fuel payment	Pharmacy Drive-through payment
Fast food payment	Repair-service record
Electronic licence plate	Rental car processing
Traffic information	In-vehicle signing
Work zone safety warning	Highway/rail intersection warning
Intersection collision avoidance	Emergency vehicle signal pre-emption
Transit vehicle signal priority	Transit vehicle data transfer
Rollover warning	Weigh-station clearance
International border clearance	Vehicle and cargo tracking
Rail engine to grade crossing	Unique CVO fleet management
Vehicle safety inspection	Daily log
Railroad database transfer	Truck tractor-trailer data transfer
Collision avoidance	Rail engine fuelling control
On-board safety data	

Table A.1

	Application	Description
1	Automatic Fee Collection (AFC) Access	Charges for use of roads at point of use / allows access to controlled area.
2	Traffic Information	Sends data to car advising of traffic congestion, poor visibility ahead.
3	Route Guidance	Advises driver on traffic flow problems ahead and alternative routes.
4	Traffic monitoring	Gathers information for traffic management.
5	Parking Management	Enables driver to check ahead on availability of parking and to pre-book.
6	Freight and Fleet Management	Efficient management of freight and fleet. For example, locates vehicles and transmits nature of cargo to save time at border controls.
7	In car internet / PC mobile office	Provides an internet style access of telematic data.
8	Co-operative Driving	Alerts driver to other vehicles braking, changing lane etc.
9	Platoons / Road trains	Organizes a number of vehicles into convoys.
10	Emergency warning	Alerts driver to sudden manoeuvres or failures of nearby vehicles.
11	Intelligent Intersection Control	Alerts driver to other vehicles at intersections.
12	Feed from radio station	Local, national or international radio stations stream live (only with Node backhaul) or pre-recorded (content on Node) via Nodes.
13	Stolen Vehicle Alarm, tracking and recovery	Unauthorized movement of vehicle (or boat) is detected and authorities alerted. Vehicle is then tracked for recovery similar to current Tracker system already in use.

A.2 Market size, value and type

The World market for ITS and RTTT services is growing rapidly, and European commercial and technical interest is strong. Approximately 50 million new vehicles enter the world market each year: if the forecourt value of equipment is 200 Euros, with a geometrically progressive adoption to 60 % installation by 2020, then this equates to approximately 160 Million vehicle fits, and 32 Bn Euros of vehicle equipment value. Similarly there are about 1 million kms of inter-city trunk standard road in Europe: at 0,5 km linear density in both directions, this is 2,4 million units, which at a minimum unit cost of 2 500 Euros, adds another 6 Bn Euro directly. Transacted trade and road safety and control value is very much more difficult to predict, the value given is very conservatively estimated to be 53 Bn Euros.

At present, the number of applications implemented is small compared with the number considered to be valuable by analysts drawn from the automotive industry, road operators, road users, governmental and environmental bodies. Key requirements for growth are effective, multi-application communication systems that provide a technical platform, and a set of service providers responsive to the users' needs and to the economic/commercial opportunities.

The 63 GHz to 64 GHz communication system outlined in the present document is an example of a system that has the capability of meeting a wide range of the data link requirements, through its scope for a high data rate, time-division and/or channelized architecture.

The anticipated roll-out is through installation of roadside units on existing roadside infrastructures. These, in turn, provide services which will increase in number and complexity to vehicles equipped with an in-vehicle unit. As more vehicles are equipped, so the number and value of services will grow.

It is planned that roadside units will be placed at regular intervals along all inter-urban trunk routes, at strategic locations (junctions, services etc) on more minor roads, and at locations of opportunity (e.g. sides of buildings, lamp posts, traffic signs) in urban areas.

In-vehicle units will eventually be fitted to all new vehicles (domestic and commercial), and retro-fitted on an operator/owner-demand basis to a proportion of existing vehicles.

It is expected that full roll-out will require a decade, but that installations will start in 2006/07 with early adopters (vehicles) and points of need (roadside) providing a realistic and useful service within 24 to 36 months.

It is important that the use of the communication system is available both for official (i.e. safety, public information and road management) and for commercial purposes, so that viable business cases can be established, with the commercial use being critical in providing a payload that enables the capital expenditure that allows the system to be adopted on the scale required.

The standards for operation must be developed with a technology neutral approach such that an evolutionary roll-out is possible, so as not to disadvantage early adopters, but to allow faster data rates in the future as technology improves, thus there is a need to design in both backward and forward compatibility.

Although the road environment is the one which is mainly addressed in the present document, the techniques and benefits are equally relevant for multi-modal transport, for example light rail, inland water-borne and for aircraft ground movement applications.

A.3 Market value projections

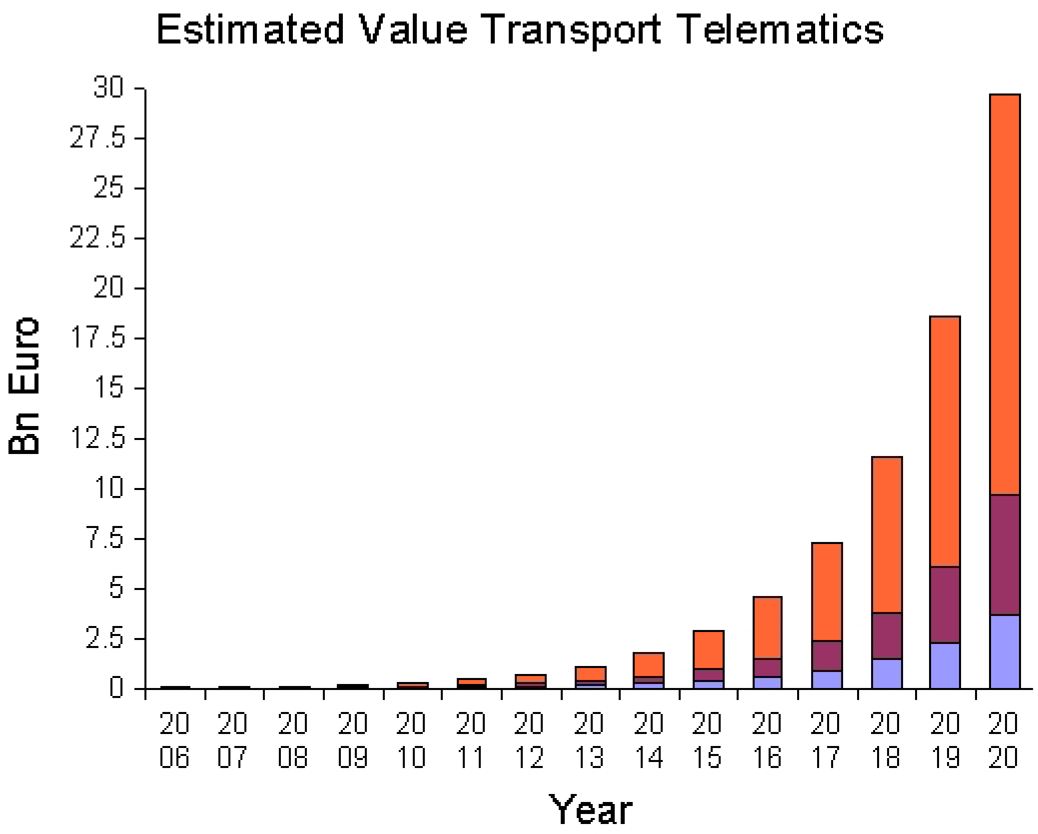

Figure A.1

Key: Blue = value of roadside units annually

Maroon = value of vehicle fits annually

Orange= value of trade over the network annually

Assumptions

- total vehicles entering the world market are assumed at 50 million annually;
- the proportion of these that are equipped for Transport Telematics rises to 60 % in 2020;
- the total length of roads that will be equipped is assumed to be 1 million kms representing main trunk roads that are predominately multi-lane (cf. 35 000 km UK 57 000 km Germany etc);

- the density of roadside units is 4 per km and 60 % of such roads are equipped in 2020;
- trade value is estimated by taking 2 % of the current global expenditure on promotion of goods and services (from generally accepted world advertising volume) and assuming that the providers of goods and services will transfer at least this amount to offering commercial services to drivers of vehicles (albeit in very different and acceptable formats).

The model assumes a constant adoption rate of 60 % year on year.

A.4 Traffic evaluation

The functionality required of a millimetric, high data rate communication system for next-generation transport telematics is that it should support IVC and RVC in a dynamic traffic environment, in a range of weather conditions, and with communication ranges extending to several hundred metres. It must be capable of providing broadcast, point-to-point and vehicle cluster connectivity.

The communications traffic will be distributed over a wide area of a country, with a user density dependent on the scenario.

In an inter-urban situation, there could be 100 emitters per km in each direction for a multi-lane road, and up to 10 emitters per km on a single track rural road. In the urban environment, there may be 1 000 emitters per sq km.

Annex B: Technical information

B.1 Detailed technical description

B.1.1 Technical background

Intelligent Transport Systems (ITS) and Road Transport and Traffic Telematics (RTTT) systems will depend for their implementation on a variety of communications and sensing systems. Most of these systems can be supported by appropriate use of the band 63 GHz to 64 GHz. This band offers several advantages to be described in later clauses.

The last decade has seen significant advances in manufacturing technology, component technology and compact integration. Such advances have reached the critical mass necessary to invest in the design and construction of these novel systems with some European companies now in the design phase and thus the requirement for standards and inter alia this generic system reference document. New systems are expected to reach the market in less than two years.

The use of frequencies in this range permits the development of relatively wide-band, high data rate systems. In turn, this relieves system designers of a major constraint and enables flexibility in the realization of systems that can meet the expectations of all stakeholders. Both high data rates and multiple applications become possible. The short wavelengths also confer flexibility in design the design of antennas, enabling the use of many forms, from simple horns to complex dielectric structures. A range of beam sizes and shapes become possible ensuring that the desired properties are achievable in discrete or conformal physical arrangements. Even lane-limited systems are possible.

The frequency band is close to a peak in the oxygen absorption, permitting these short range devices to re-use spectrum in quite short distances, again increasing the implementation choices while avoiding the constraints present at lower frequencies, for example at some complex motorway junctions.

Communications links expected to be implemented in this band include both vehicle-to-roadside and vehicle-to-vehicle (forward and reverse). The band is not expected to include anti-collision radar.

It is relevant that ISO TC204 WG16 is working towards an architecture (referred to as CALM) that allows a range of applications to be matched to a set of communication bearers, with a management layer determining the linkage according to the requirements of the applications and the functionality of the bearer. A millimetric communication system is envisaged as being one of these bearers, and so an appropriate interface must be provided to allow interoperability with the CALM architecture.

B.1.2 Draft system parameters

Table B.1 summarizes some draft system parameters and is not exhaustive. It should be noted that the system requirements for the roadside-to-vehicle and vehicle-to-roadside links are not necessarily identical. In order to allow for flexible and efficient spectral usage, a number of modulation schemes are proposed.

The parameters given in table B.1 are examples only, but are based on the requirements of a range of applications for millimetric data links for RTTT and what is believed to be feasible. It also takes into account the experience gained with a prototype, networkable data link operating in the band 63 GHz to 64 GHz which has been successfully demonstrated and which uses a card running IEEE 802.11a [4] as its source of IF. The latter protocol has its own set of pre-determined modulation schemes and data rates along with a MAC. Lessons have been learnt in relation to beneficial combinations and those best avoided. The parameters in table B.1 are consistent with these, while the range of options for some parameters has been expanded to an extent believed to be readily achievable in practice. The notes by each parameter give more specific detail on the reasons for the choices.

Table B.1: Several draft system parameters

Parameter	Value	Comments
Maximum mean radiated power	40 dBm EIRP	A variety of antennas may be used according to the specific application, but maximum mean EIRP powers of 40 dBm will give adequate coverage for roadside-to-vehicle, vehicle-to-roadside and inter-vehicle. There may be situations in which one type of connection will be set to have a reduced power if, for example, there is asymmetry in the data rates.
Antenna beam shape/gain	20±5 dBi 10±3 dBi	A variety of antennas may be used according to the specific application. Fixed beacon antennas may need to have different characteristics from those on mobile transceivers.
Polarization	Circular Linear	Circular polarization may be used for multipath mitigation. Orthogonal polarizations may be used to reduce interference between vehicles travelling in opposite directions, for example.
Modulation scheme	BPSK QPSK FSK DPSK M-ary QAM	Adaptive modulation schemes may be employed to cater for the diverse scenarios. High order schemes are not preferred because of constraints imposed on some component parameters. OFDM may be beneficial for multipath resilience.
Data rates (per channel)	Up to 120 Mbit/s in each channel	A single IF channel of 25 MHz bandwidth could support up to 120 Mbits/s in favourable conditions. Lower data rate channels would be used where a longer propagation range was required.
Channel options (IF)	Up to 16 channels	16 IF channels (each of 25 MHz bandwidth) separated by guard bands will be available in the 63 GHz to 64 GHz bandwidth to mitigate interference between users.
Channel options (RF)	Up to 16 channels	A number of adjacent IF channels may be combined in an RF channel to achieve higher data rates.
Communication mode	Full-duplex Fast switching half-duplex TDD	The choice of communication mode will depend on the data service in operation. Time division duplexing (TDD) may be considered. Full-duplex transceivers present a greater technical challenge in their design and construction. A prototype full-duplex design has been successfully demonstrated.

B.2 Technical justification

B.2.1 Background

New spectrum is not required. CEPT has already identified the frequency range from 63 GHz to 64 GHz for IVC and RVC, with the intention of determining the required power level at a later stage [1].

The power level proposed in clause B.1.2 enables single-hop communication ranges up to 300 m to be supported, with a variety of data rates and in a range of weather conditions.

It is worth noting that the use of frequencies in the 63 GHz to 64 GHz range requires higher transmitted power levels than do lower frequency systems to get a similar performance, due in part to the oxygen absorption in this band. It must be recognized that the latter effect is one of the reasons why this band is beneficial for high density IVC and RVC since transmissions are effectively limited beyond the designed range, thereby reducing interference and providing a short reuse distance so that complex frequency planning is unnecessary. Compensation for higher losses can be easily made through the appropriate use of antenna gain. At these frequencies beam shaping can ensure that the radiated energy is placed just where it is needed. The use of novel types of antenna such as plasma or electronic band-gap (EBG) can be more easily implemented in this band.

Energy scattering by hydrometeors such as rain drops, fog, spray and wet snow will have an effect on the communication range, and therefore system design needs to take this into account. to allow satisfactory operation. The scattered energy is unlikely to cause interference since it is again attenuated by the losses in the environment.

It should be noted that the set of parameters in clause 6 is derived first of all from the operational requirements (as can also be seen from the link budget in clause B.2.2). In addition, it is useful to consider the power density limits from a safety perspective. The public exposure limit for the 63 GHz to 64 GHz band is 10 W/m^2 for a duration of 53 seconds. For a continuous EIRP of 40 dBm, this level is found at a range of approximately 0,28 metres (in the boresight direction). The range is correspondingly less for lower EIRP values.

For a moving vehicle, it is highly unlikely that a person could be at a range less than 1 metre for 53 seconds, on the assumption that the antenna is directed parallel to the direction of travel. At lower speeds or when the vehicle is stationary, situations could be envisaged when the power density limit is exceeded, and so a reduction in maximum mean power can be arranged (either reducing the field level or having an intermittent transmission).

The duration of 53 seconds is for the public exposure limit measurement as in CENELEC EN 50392 [9]. For comparative purposes, it should be noted that a typical ITS message duration is in the range of 1 or a few millisecond.

Because there is a minimum antenna gain, it is beneficial to introduce a maximum total transmitted power to avoid the situation in which a high power flux density could be obtained when a low gain antenna is used, and the only limit is on EIRP. For a roadside beacon, the power density at a specified height from the ground can be regulated by the height of the beacon as well as either of the above mentioned methods.

The above safety limit complies with field limits for human exposure to electromagnetic fields as provided by the EC Recommendation 1999/519/EC [8] and the methods for compliance demonstration in CENELEC EN 50392 [9].

If the emission limit is solely defined as an EIRP, then in the case of a low gain antenna (fed by an appropriately higher input power level) it is possible for higher values of spectral power density to be obtained, whereas for a higher gain antenna, the power flux density is reduced within the near field region of the antenna (compared with that calculated from an inverse-square model) because of diffraction effects. It is therefore beneficial to limit the input power level. The FCC regulations [10] specify a maximum peak input level of 500 mW.

B.2.2 Link budget

Communication along boresight of a directional antenna is considered. Analysis of the communication requirements of a number of diverse applications results in a range of data rates to be achieved over links of variable distances, however typical values for common system parameters may be used in the link budget calculations. Given a particular SNR at a receiver, it is possible to calculate an accompanying data rate, however, in some applications considered in the present document, other factors may contribute to the overall achievable data rate.

Table B.2 shows some typical system parameters used to calculate the link budget for the vehicle-to-roadside links.

Table B.2: Typical system parameters

Parameter	Value	Units
Carrier frequency	63,5	GHz
Transmit power (pre-antenna)	18	dBm
Power amp backoff	6	dB
Tx antenna gain	25	dBi
Tx antenna efficiency	75	percent
Rx antenna gain	13	dBi
Rx antenna efficiency	75	percent
Ambient temperature	293	K
Boltzman's constant	$1,38 \times 10^{-23}$	$m^2\ kg\ s^{-2}\ K^{-1}$
Receiver noise figure	6	dB
Symbol rate	20	MHz
Nyquist filter	Root raised cosine	-
Roll-off factor	0,25	-
Oxygen absorption	11	dB/Km
Link margin	6	dB

Using the parameters detailed above, an SNR in excess of 20 dB is achievable at a range of 200 metres.

B.3 Information on current version of relevant ETSI standard

A Harmonized Standard has not yet been adopted for these devices. However, a new ETSI work item for the creation of such a standard in ETSI ERM-TG37 has recently been adopted.

Annex C: Expected compatibility issues

C.1 Coexistence issues

From the European Common Allocation Table [6], the primary co-existence issue to consider is that of interference to the Mobile Service and to the Radiolocation Service.

Table C.1: Excerpt from the European Common Allocation Table [6]

Frequency band	European Common Allocation	Utilization	ECC ERC Document	Note
63 GHz to 64 GHz	INTER-SATELLITE MOBILE 5.558 (see note 1) RADIOLOCATION 5.559 (see note 2)	Short range non civil radiolocation (62 GHz to 64 GHz) RTTT	ECC DEC (02)01 ERC REC 70- 03	Road Transport and Traffic Telematic Vehicle to road/ vehicle to vehicle
NOTE 1: Footnote 5.558 states: 'In the bands 55.78-58.2 GHz, 59-64 GHz, 66-71 GHz, 122.25-123 GHz, 130-134 GHz, 167-174.8 GHz and 191.8-200 GHz, stations in the aeronautical mobile service may be operated subject to not causing harmful interference to the inter-satellite service (see No.5.43). (WRC-2000)'				
NOTE 2: Footnote 5.559 states: 'In the band 59-64 GHz, airborne radars in the radiolocation service may be operated subject to not causing harmful interference to the inter-satellite service (see No.5.43). (WRC-2000)'				

On account of the high atmospheric absorption at ground level (approx. 11 dB/km) which provides a usefully low re-use distance, compatibility with the services above in the same band is expected to be less of a problem than it would be for lower frequency operation (e.g. in the microwave band). In addition, directional antennas are likely to be used, directed along the line of the road, so that the energy is effectively confined to a corridor with a restricted width and height.

Isolation to typical ISS links between satellites in LEO is expected to be at least 200 dB. For the Mobile and Radiolocation services, isolation of the order of 120 dB or more can be expected. Compatibility studies will be required to verify the protection afforded to existing systems known to use the band.

C.2 Current ITU allocations

The ITU Radio Regulations [7] lists in Regions 1, 2 and 3:

Table C.2: Excerpt from the ITU Radio Regulations [7]

Frequency band	Allocation
59,3 GHz to 64 GHz	FIXED INTER-SATELLITE MOBILE 5.558 (see note 2) RADIOLOCATION 5.559 (see note 3) 5.138 (see note 1)
NOTE 1: Footnote 5.138 states: "The following bands: - 6 765-6 795 kHz (centre frequency 6 780 kHz), - 433,05-434,79 MHz (centre frequency 433.92 MHz) in Region 1 except in the countries mentioned in No.5.280 , - 61-61,5 GHz (centre frequency 61,25 GHz), - 122-123 GHz (centre frequency 122,5 GHz) and - 244-246 GHz (centre frequency 245 GHz) are designated for industrial, scientific and medical (ISM) applications. The use of these frequency bands for ISM applications shall be subject to special authorization by the administration concerned, in agreement with other administrations whose radiocommunication services might be affected. In applying this provision, administrations shall have due regard to the latest relevant ITU-R Recommendations".	
NOTE 2: Footnote 5.558 states: "In the bands 55.78-58.2 GHz, 59-64 GHz, 66-71 GHz, 122.25-123 GHz, 130-134 GHz, 167-174.8 GHz and 191.8-200 GHz, stations in the aeronautical mobile service may be operated subject to not causing harmful interference to the inter-satellite service (see No.5.43). (WRC-2000)"	
NOTE 3: Footnote 5.559 states: "5.559 In the band 59-64 GHz, airborne radars in the radiolocation service may be operated subject to not causing harmful interference to the inter-satellite service (see No.5.43). (WRC-2000)"	

C.3 Sharing issues

Services known to exist include systems in the aeronautical mobile service, in particular communications between aircraft. These are generally low power and used at altitude, thus oxygen absorption provides significant protection for these systems. As a consequence this service is not expected to present any compatibility issues to links serving RTTT systems.

Systems in the Radiolocation Service could be used occasionally in close proximity to RTTT systems. Again significant protection can be obtained from the isolation afforded by oxygen absorption and the off-axis antenna gain present between these systems. Again, this is not expected to present particular difficulties, but the isolation will be less than in the case of aeronautical mobiles. This may require a compatibility exercise.

History

Document history		
V1.1.1	April 2005	Publication (withdrawn)
V1.2.1	July 2006	Publication