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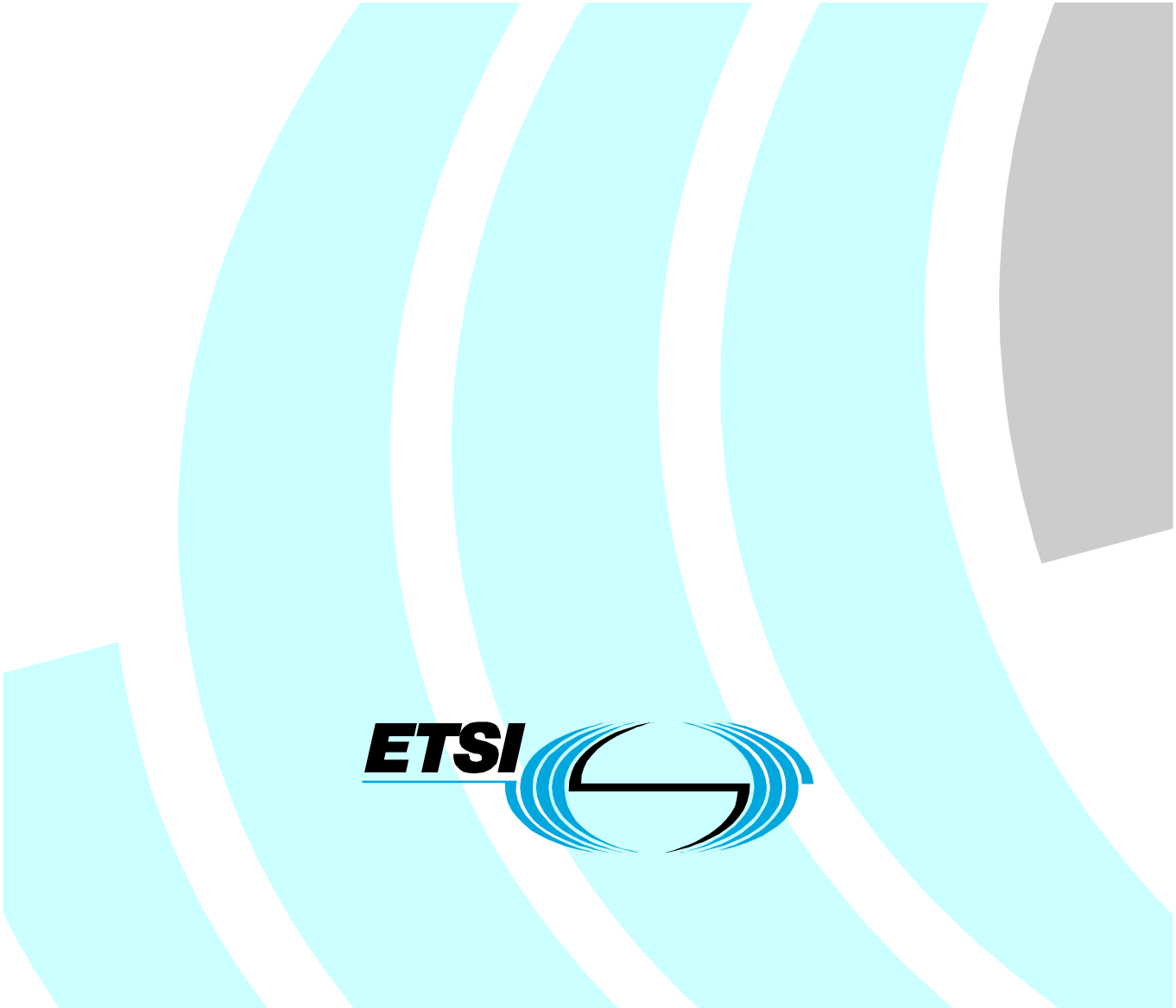
Technical Report

Electromagnetic compatibility and Radio spectrum Matters (ERM); Intelligent Transport Systems (ITS); Part 2: Technical characteristics for pan European harmonized communications equipment operating in the 5 GHz frequency range intended for road safety and traffic management, and for non-safety related ITS applications; System Reference Document



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Foreword

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

The present document is part 2 of a multi-part deliverable covering Intelligent Transport System (ITS) as identified below:

Part 1: "Technical characteristics for pan-European harmonized communications equipment operating in the 5 GHz frequency range and intended for critical road safety applications; System Reference Document";

Part 2: "Technical characteristics for pan European harmonized communications equipment operating in the 5 GHz frequency range intended for road safety and traffic management, and for non-safety related ITS applications; System Reference Document".

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).

The proposal for frequency designation in part 2 of the present document is closely related to the proposal for frequency designation in part 1:

- Part 1 covers the minimum requirements for road safety applications with focus on inter-vehicle communications (IVC) with very low latency.
- Part 2 covers the required additional spectrum, with focus on roadside-to-vehicle communications (RVC) applying mobile networking based on the internet protocol IPv6 as well as other protocols.

It is recommended to have a contiguous band, or at least nearby bands, designated for parts 1 and 2.

In addition to the fundamental time-critical road safety applications as described in part 1, part 2 extends the applicability of the communications equipment towards other road safety and traffic management tasks.

Furthermore, the present document also covers vehicle-to-vehicle and roadside-to-vehicle communications for non-safety related applications.

The reasoning for road safety and traffic management applications is provided in part 1 and will not be repeated here.

In addition, the present document also covers roadside-to-vehicle applications which are designed to increase the road traffic efficiency and traffic flow. Both types of applications indirectly enhance the traffic safety.

1 Scope

The present document describes the spectrum usage requirements for equipment related to:

- primarily roadside/infrastructure to vehicle communications (RVC);
- inter-vehicle communications (IVC).

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 in annex A.
- Technical information in annex B.
- Expected compatibility issues in annex C.

2 References

For the purposes of this Technical Report the following references apply:

[1] Final report of the e-Safety Working Group on Road Safety http .

NOTE: See http://www.europa.eu.int/information_society/programmes/esafety/index_en.htm

[2] CEPT ECC/DEC/(04)08 of 12 November 2004 on the harmonised use of the 5 GHz frequency bands for the implementation of Wireless Access Systems including Radio Local Area Networks (WAS/RLANs).

[3] IEEE 802.11p: "Wireless Access for Vehicular Environments - Draft standard".

[4] FCC Rules and Regulations, (August 3, 2004): "Regulations governing the licensing and use of frequencies in the 5850 - 5925 MHz band for Dedicated Short Range Communications Service".

[5] ISO 21210: "Intelligent Transport Systems - CALM - Medium and long range, high speed, air interface parameters and protocols for broadcast, point - point, vehicle - vehicle, and vehicle -point communications in the ITS sector - Networking Protocol - Complementary element".

[6] ISO 21215: "Intelligent Transport Systems - CALM -Medium and long range, high speed, air interface parameters and protocols for broadcast, point-point, vehicle-vehicle, and vehicle-point communications in the ITS Sector - Air interface using 5 GHz communications".

[7] ISO 21217: "Intelligent Transport Systems - CALM -Medium and long range, high speed, air interface parameters and protocols for broadcast, point-point, vehicle-vehicle, and vehicle-point communications in the ITS Sector - System architecture".

[8] ISO 21218: "Intelligent Transport Systems - CALM -Medium and long range, high speed, air interface parameters and protocols for broadcast, point-point, vehicle-vehicle, and vehicle-point communications in the ITS Sector - Medium Service Access Points".

[9] ETSI EN 300 674: "ElectroMagnetic Compatibility and Radio Spectrum Matters (ERM); Road Transport and Traffic Telematics (RTTT); Technical characteristics and test methods for Dedicated Short Range Communication (DSRC) transmission equipment (500 kbit/s / 250 kbit/s) operating in the 5,8 GHz Industrial, Scientific and Medical (ISM) band".

3 Definitions and abbreviations

3.1 Definitions

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

inter-vehicle communications: generic expression for bi-directional communications between vehicles

NOTE: May include multi-hop routing involving several vehicles.

on-board unit: radio, transmitter and receiver, usually installed in a vehicle

road-side unit: radio, transmitter and receiver, usually fixed as part of the road infrastructure:

- installed along the road, e.g. on gantries above the lane or at poles beside the lane;
- 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;
- Internet access.

roadside-to-vehicle communications: also referred to as downlink communications

roadside-vehicle communications: generic expression for communications between a roadside and a vehicle, which may include both downlink and uplink communications

NOTE: May include multi-hop routing involving several vehicles, may allow for internet access, may be based on handover between adjacent roadside units.

vehicle-to-roadside communications: also referred to as uplink communications

WAVE: the name of IEEE 802.11p [3] group and technology

3.2 Abbreviations

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

ACC	Automotive cruise control
CALM	Continuous Air interface Long and Medium range
CALM M5	CALM for the 5GHz Microwave range
C2C-CC	Car-to-Car Communication Consortium
dBm	Power in decibel relative to 1 mW
DFS	Dynamic Frequency Selection
DSRC	Dedicated Short Range Communication
ECC	Electronic Communication Committee
e.i.r.p.	equivalent isotropically radiated power
GSO	Geostationary Satellite Orbit
IEEE	Institution of Electrical and Electronic Engineers
IPv6	Internet Protocol version 6
ISO	International Standards Organisation
IVC	Inter-Vehicle Communications
ISM	Industrial, Scientific and Medical
ITS	Intelligent Transport Systems
LBT	Listen-Before-Talk
OBU	On-Board Unit
OEM	Original Equipment Manufacturer
R2V	Roadside-to-Vehicle

RLAN	Radio Local Area Network
RSU	Road-Side Unit
RVC	Roadside-Vehicle Communications
RTTT	Road Transport and Traffic Telematics
TPC	Transmit Power Control
TR	ETSI Technical Report
V2R	Vehicle-to-Roadside
V2V	Vehicle-to-Vehicle
WAS	Wireless Access System
WAVE	Wireless Access in Vehicular Environments
WLAN	Wireless Local Area Network

4 Executive summary

4.1 Status of the system reference document

ERM RM#29 decided to forward working version 1.1.1_0.0.6 of the system reference document to CEPT/ECC-WG FM to provide preliminary information about ITS to the ECC. RM#29 also decided to split the document into a 3-part System Reference document in order to clarify the individual requirements for the different ITS applications.

It is also to be noted that spectrum usage as proposed in the present document is no longer envisaged to be on a national basis but rather on a pan European basis in order to avoid coordination/protection zone issues along borders. It also favours the usage by vehicles that travel cross border and operate in countries other than their home country.

ERM-TG37 during its meeting in February 2006 decided to withdraw part 3 of the System Reference document, which requested a higher maximum transmission power for the WAS/RLAN band from 5,470 GHz to 5,725 GHz, as defined in ECC DEC(04)08 [2]. This decision was based on the fact that the considered spectrum is not available for inter-vehicle communications due to the DFS requirements, and communications between roadside units and vehicles can be operated at a lower level of transmission power.

The present document was revised by ERM RM#33 and approved for submission to TC ERM.

4.2 Spectrum requirement and justification

The spectrum requirement includes 30 MHz of bandwidth for road safety and traffic management related ITS applications mainly based on communications between roadside units and vehicles. Additional 20 MHz of bandwidth are required for non-safety related ITS applications based on inter-vehicle and roadside-to-vehicle communications. These services and applications should be available Europe-wide. The communications supports mobile networking using the internet protocol Ipv6 as well as other protocols.

Important conditions to note are:

- Road safety and traffic management services need a predictable sharing environment which is not available in the WAS/RLAN band from 5,470 GHz to 5,725 GHz and the ISM-band from 5,725 GHz to 5,875 GHz.
- Car manufacturers and their suppliers require that the same radio subsystem can be used in all cars. The usage of the same antenna in all regions is an important cost factor for the OEMs, because the shape of the car has a large influence on the antenna design.
- The spectrum for ITS services must be individual license free.

For cost reasons, it is recommended to assign spectrum contiguous to the pan European harmonized 2 (two)·10 MHz spectrum requested in part 1 of the present document.

4.3 Market information

The recent increase in maturity of WLAN technology and availability of high-performance, low-cost products caused commercial interest in practical systems for ITS applications based on this technology.

Mobile networking is an increased demand, thus WLAN technology was further developed for applicability in a highly dynamic traffic environment (see IEEE 802.11p [3]), based on mobile IPv6 protocols, e.g. as used in ISO TC204 WG16 CALM [7].

Further information is provided in annex A.

4.4 Technical system description

This information is provided in annex B.

5 Current regulations

The current regulation provides the frequency bands a) from 5,795 GHz to 5,805 GHz and b) from 5,805 GHz to 5,815 GHz for road to vehicle systems, particularly but not exclusively for road toll systems. For band b) some countries have restrictions on use. Because these bands are in the ISM band ranging from 5,725 GHz to 5,875 GHz, sufficient predictable sharing conditions as required for road safety and traffic management related RTTT/ITS services are not available.

The spectrum range from 5,470 GHz to 5,725 GHz is provided as an individual license free band for WAS/RLAN under the regulatory regime as presented in ECC DEC(04)08 [2], open for outdoor usage. Due to the required DFS procedure the applicability of the WAS/RLAN frequency band for ITS applications is limited to communications between roadside units and vehicles.

Another band assigned for RTTT, allowing for IVC and RVC is given from 63 GHz to 64 GHz. The signal propagation in this band requires line of sight conditions, which significantly limits the communication possibilities. Stable omni-directional antenna patterns are very hard to produce in the 63 GHz to 64 GHz band. IVC can only be realized between vehicles in the immediate vicinity. Also RSU operating at this frequency cannot provide large communications zones due to shadowing effects caused by trucks etc. Consequentially not all the ITS applications considered for a communication system at 5 GHz can be implemented at 63 GHz. Furthermore system introduction is more critical, because with line of sight conditions the required penetration rate of equipped vehicles must be higher to provide sufficient communications.

Nevertheless the directivity and signal attenuation in the band from 63 GHz to 64 GHz are features, which can be seen as an advantage for other ITS applications, that are not in the focus of the present document.

6 Proposed regulation

6.1 Spectrum

It is proposed to assign 50 MHz of spectrum contiguous to the pan European harmonized 2 (two)·10 MHz spectrum requested in part 1 of the present document, preferably within the frequency range from 5,850 GHz to 5,925 GHz.

The reasoning for road safety and traffic management applications is provided in part 1 and will not be repeated here.

It is proposed to provide 30 MHz of spectrum for these road safety related applications and also for road traffic efficiency and traffic flow application in the spectrum above the ISM frequency band (i.e. above 5,875 GHz) in order to provide predictable sharing conditions. This is in addition to the request presented in part 1 of the present document but with the focus on roadside-to-vehicle communications.

In addition, 20 MHz of spectrum are requested for non-safety related applications based on inter-vehicle and roadside to vehicle communications, which do not require predictable sharing conditions and may therefore also be provided within the ISM-frequency range (i.e. below 5,875 GHz).

Further, it is to note that Roadside-to-Vehicle Communications (RVC) can apply the DFS-mechanism as required below 5,850 GHz. Inter-Vehicle-communications (IVC) cannot apply the DFS mechanism because of the highly dynamic environment where e.g. DFS channel scanning is considered to be much too long. In RVC communications, the roadside unit will always commence communications and therefore, would apply the DFS mechanism similar to the WLAN approach.

Figure 1 presents the preferred spectrum for TR 102 492 parts 1 and 2.

Dedicated channel spacing is not proposed to be regulated. Typical channel bandwidths considered in IEEE 802.11p [3] are 10 MHz to 20 MHz wide channels. In addition, ETSI standards will define the exact channelization and frequency usage prioritization concept (safety and possibly efficiency applications as well as control channel will be prioritized on protocol level).

These channels will be open for the applications within the respective usage category (either road safety related or not, i.e. used for traffic management).

The required power level (e.i.r.p.) range is from 3 dBm to 33 dBm to achieve communication distances of up to 1 000 m. The related maximum power spectral density (e.i.r.p.) is 23 dBm/MHz.

Transmitter Power Control with a dynamic range of 30 dB is used.

It should be noted that most roadside-to-vehicle applications will require a much shorter communications distance than 1 000 m and therefore, lower power levels than 33 dBm are involved on average. If it is considered an average range of 300 m in rural areas, one needs an e.i.r.p not exceeding 19 dBm.

Due to the wide range of potential future ITS applications, an estimation of a typical duty cycle is difficult. However, many applications show characteristics of rather short message communications with low duty cycles.

The advantage of this proposal is to provide the best possible harmonization with the FCC regulation [4].

As the present document is an extension of part 1 of this multi-part deliverable with regard to roadside-to-vehicle communications, see as well the reasoning provided in part 1.

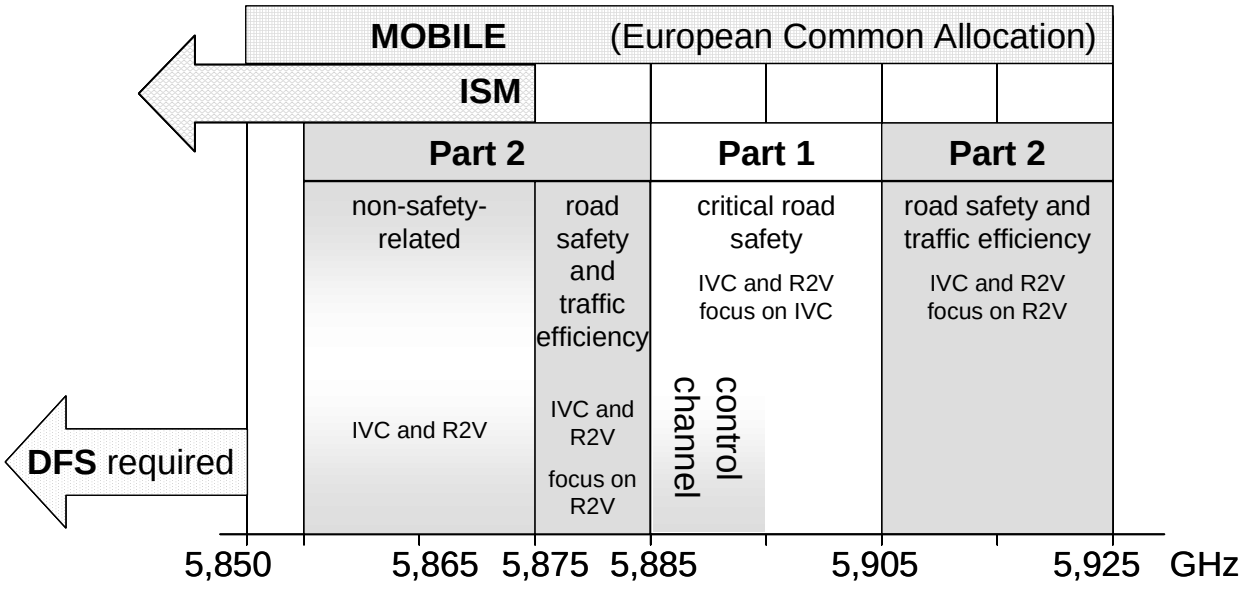

Figure 1: Preferred ITS spectrum

6.2 Requested licensing conditions

The spectrum for ITS services must be individual license free.

Important conditions to note are:

- It is a public concern to improve road safety and traffic flow, and as such politically prioritized.
- The practical problems of licensing in a global car market are immense.
- It is a common experience of the car manufacturers that neither drivers nor car holders are willing to pay for the operation of safety systems, e.g. data transmission fees.
- ITS services are expected to have a very slow take-off if there are costly licensing policies.

6.3 Global usage

As different types of safety and traffic management related communication systems hinder safety and limit efficiency, and considering cost of equipment, usage of standardized components is a prerequisite. Thus, a high degree of harmonization of frequencies on the global level is necessary, since needs for these applications exist throughout the world, and since vehicles are marketed in the global marketplace.

7 Main conclusions

7.1 Business importance

The need for ITS data communication and a suitable frequency designation has been recognized for several years. Europe was pioneering the use of microwave communication with the RTTT DSRC systems at 5,8 GHz, and is now working straight forward to more capable microwave solutions enabling mobile communications between vehicles, and between roadside units and vehicles, both for low latency applications, and for sophisticated networking applications using the internet protocol Ipv6 as well as other protocols.

A fast and versatile communication system platform is needed to support the large number of RTTT/ITS applications, including safety and traffic management applications.

The primary public objective is to reduce the number and severity of automobile accidents and to provide road operators a system to control and manage the traffic on their road network.

The ISO standards group TC204 WG16 prepared a specification for an architecture (see ISO 21217 [7]) 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. It is recognized that all bearers cannot support all applications, and that there will be circumstances which favour one over another.

The ITS functionalities as described in all parts of the present document will be implemented in one single system.

The ITS concept is therefore developed to provide a solution that is open for parallel communication sessions between vehicles and the infrastructure, or between vehicles, thus providing mechanisms that give the safety relevant applications the highest priority all the time.

Microwave systems in the 5 GHz range can offer communications with a high data rate, ranges up to 1 000 m, low weather-dependence, and global compatibility and interoperability (see IEEE 802.11p [3] and ISO 21215 [6]).

Spectrum on a European-wide basis is needed as ITS systems should enable communications between vehicles and the infrastructure, and between vehicles, in an environment where the vehicle marketplace is global and manufacturers providing vehicle models on a global basis with the minimum of variation to meet local national requirements.

Vehicles frequently travel cross border and operate in countries other than their home country. This is particularly true for commercial vehicles, and for most vehicles within the North/Western part of Europe. Different national spectrum allocations with guard zones along the borders will be very hard to manage in this highly mobile environment. Vehicle manufacturers want to equip vehicles with a single global solution. They do not want the complexity, and risk, of too many uncoordinated communications systems providing different services.

7.2 Expected timing for ITS to market in Europe

It is intended to place commercial ITS products on the market, i.e. built into cars, by 2008. Under the assumption that it would take approximately 2 years for planning and preparing the incorporation of ITS in cars, a definite frequency decision from CEPT is required before the end of 2006/beginning of 2007 to support adequate and secure planning efforts.

7.3 Expected ECC and ETSI Actions

ECC is already investigating in response to the already delivered part 1 of the present document, 1 x 10 MHz in the upper part of the ISM band (from 5,865 MHz to 5,875 MHz) as proposed by SRDMG and 2 x 10 MHz channel (from 5,875 MHz to 5,895 MHz) as proposed by ETSI.

Concerning this part 2, ETSI requests the ECC to perform the following actions:

- Investigate and identify suitable spectrum for ITS services and applications in addition and close to the frequency range already under investigation. As part of the ECC action, ECC should consider the recommendation in clause 6 of the present document.
- Perform necessary compatibility studies in the process of identifying the most suitable spectrum for ITS in Europe.
- Develop and adopt a CEPT ECC Decision that would allow for ITS to be introduced in the European markets by 2008. A frequency decision from CEPT is required before the end of 2006/beginning of 2007 to support the eSafety [1] initiative and enable adequate and secure planning efforts by authorities and industry.

ETSI actions:

- ETSI intends to develop standards for ITS in ERM TG37 to cover the technical operational specifications and measurement requirements for ITS devices that are the subject of the present document.
- Co-existence issues between ITS IVC units as interferer and RTTT DSRC (from 5 795 GHz to 5 815 GHz) OBUs [9] as victim, both installed in the same car, will be investigated. ETSI ERM-TG37 members intend to address this concern by conducting measurements to investigate the situation. This item may be considered as an ITS/RTTT intra-applications issue and possible technical solutions will be investigated in ETSI ERM-TG37.

Annex A:
Market information

A.1 Summary of application types

A.1.1 Overview

Lists of applications for IVC and RVC have been investigated by various projects and groups, and the number of applications is still increasing.

The connectivity required by the applications can be summarized as:

1) Vehicle-to-roadside (uplink) and roadside-to-vehicle (downlink), (main focus of the present document):
   - OBU to one RSU.
   - RSU to one OBU.
   - RSU to many OBUs; broadcast.
   - RSU to selected OBUs; multicast.
2) Inter-vehicle (including multi-hop routing involving several vehicles):
   - Linear, e.g. for convoys of vehicles.
   - Vehicle cluster covering several lanes, co-directional.
   - Vehicle cluster including opposite direction of travel.
3) Communications cluster of vehicles including RSU.

A.1.2 Situation outside Europe

See TR 102 492-1 for a detailed presentation.

A.1.3 Examples of applications

The road safety and traffic efficiency applications are the driving interest in this technology from both car manufacturer and public authorities or road operators.

Road safety and traffic efficiency are global concerns, and the development in all countries shows that new technology is needed to make the grade. The worldwide ITS research has invested a lot of work in the analysis of accident reduction by IVC and RVC.

Due to economy reasons and not to overload vehicles with different communication systems, the communication system should allow for both road safety related or traffic efficiency applications and non-safety related applications, which are in the present part of the present document based on inter-vehicle communications.

The distinction between traffic management applications and safety related applications is crucial, as finally every traffic management application, at least to some extend, contributes to road safety.

The following lists are neither exhaustive nor complete and continue to expand as ITS evolves. However, they give an indication of the types of applications that the present part of the present document focuses on.

A.1.3.1 Safety related and traffic management applications

Several applications of this category are listed already in part 1 of the present document and are not repeated here.

Application	Description	V2V	V2R	R2V
Infrastructure-Based Intersection Collision Warning	This application warns drivers when a collision at an intersection is probable.		X	X
Vehicle-Based Intersection Collision Warning	Work zone safety warning refers to the detection of a vehicle in an active work zone area and the indication of a warning to its driver.	X		
Blind Merge Warning	This application warns a vehicle if it is attempting to merge from a location with limited visibility (either for itself or for the oncoming traffic) and another vehicle is approaching and predicted to occupy merging space.		X	X
Adaptive Headlight Aiming	This application allows vehicles to aim their headlights in the direction of travel and more effectively illuminate the road ahead			X
Intelligent Traffic Flow Control	This infrastructure application uses vehicle-to-infrastructure communication and thereby facilitates traffic light signal phasing based on real-time traffic flow.		X	
Enhanced Route Guidance and Navigation	Up-to-date and localized navigation information is sent to vehicles via roadside units.			X
GPS Correction	The roadside unit is pre-programmed with its precise location, and it gives this information to passing vehicles.			X
Pedestrian Crossing Information	This application provides an alert to vehicles if there is danger of a collision with a pedestrian or a child that is on a designated crossing			X
SOS Services	This in-vehicle application will send SOS messages after airbags are deployed, a rollover is sensed, or the vehicle otherwise senses a life-threatening emergency. The emergency message will be sent from the vehicle to a passing vehicle, which stores and then relays the message when in range of a roadside unit. It will then be forwarded to the nearest local authority for immediate assistance.	X	X	
Intelligent On-Ramp Metering	This infrastructure application uses vehicle-to-roadside communication to measure real-time traffic density on the highway and dynamically alters on-ramp metering signal phasing.		X	
Free-Flow Tolling	This infrastructure application works on toll roads and uses communications for toll collection without the need for toll plazas along the roadway and therefore without reducing the traffic flow.		X	X
Blind Merge Warning	This application warns a vehicle if it is attempting to merge from a location with limited visibility (either for itself or for the oncoming traffic) and another vehicle is approaching and predicted to occupy merging space.		X	X
Cooperative Adaptive Cruise Control	Cooperative adaptive cruise control will use inter-vehicle communication to obtain lead vehicle dynamics and enhance the performance of current adaptive cruise control (ACC).	X		
Blind Spot Warning	This application warns the driver when he intends to make a lane change and his blind spot is occupied by another vehicle.	X		

A.1.3.2 Non-safety-related ITS applications based on IVC or R2V and V2R

Some IVC or R2V and V2R communications enabled non-safety-related ITS applications are shown below.

Application	Description	V2V	V2R	R2V
Cross Vehicle Messaging	People in different cars might like to chat with each other or children might play games with partners in different cars.	X		
Virtual Caravan	Support of drivers, who are heading to the same destination to stay together.	X		
Information Forwarding Provided By Roadside Units	Information, e.g. point of interest notification, provided by roadside units will be forwarded via multi-hop communications.	X		
Messaging Towards Roadside Units	Messages from a vehicle, which is not in the communication range of a roadside unit, will be forwarded via multi-hop communications towards the next roadside unit.	X		
Vehicle access control	Radio based access control at company gates or at park houses.		X	X
Fuel payment, Parking payment, Fast food payment, Other services payment	At certain locations this application enables the driver to pay via radio communications without leaving the car.		X	X
Rental car processing	Access data as well as travel data, petrol fill level at the car return etc. might be communicated at the premises of the rental company.		X	X
Remote Diagnostics	This application transmits vehicle type and failure type data to a garage or the vehicle vendor via roadside units or multi-hop car-to-car-communication.	X	X	
Map Downloads and Updates	Maps can be downloaded to a vehicle and a vehicle's existing maps can be updated by a roadside unit.			X
In car internet	When nearby a stationary public internet access point (hotspot), application can use standard IP services for applications.		X	X
Parking management	Information about free parking space might be transmitted from a RSU to passing vehicles and possibly a parking slot might be booked.		X	X
Point of Interest Notification	A roadside unit will provide information to passing vehicles periodically via broadcast.			X
Vehicle and cargo tracking	Vehicle and or cargo information is collected via vehicle to roadside communications and forwarded to a centre office, which allows e.g. to detect stolen vehicles or cargo.		X	

While R2V and V2R communications based non-safety-related ITS applications might be operated in the WAS/RLAN band from 5,470 GHz to 5,750 GHz, IVC based non-safety-related ITS applications are only covered by the present document, because of the incompatibility with the DFS requirement.

A.2 Market size and value

See TR 102 492-1 for a detailed presentation.

A.3 Traffic evaluation

The functionality required of a high data rate communication system for next-generation RTTT/ITS is that it shall support both IVC and RVC in a highly dynamic traffic environment, in a range of weather conditions, and with communication ranges extending to several hundred meters. It must be capable of providing broadcast, multicast, point-to-point and vehicle cluster connectivity.

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

However, it is to note that:

- Only one ITS transmitting device uses a frequency channel at the same time using listen-before-talk and transmitter power reduction in congestion situations.
- The frequency re-use distance depends on the ITS transmitter power and varies between 15 m to 1 000 m.
- The average conveyed ITS message duration can be assumed to be less than 1 millisecond.

Annex B:
Technical information

B.1 Technical description

See part 1 of the present document for a detailed presentation.

In addition to the part 1 description further information about the radiated power is provided.

Scalability is an important feature of an ad hoc car to car communication network. The number of participating vehicles in these networks depends very much on the traffic density and the situation on the roads. If there is a high density of vehicles, the communication range will be much below the maximum value to provide all nodes the required channel access and possibility to transmit data.

Furthermore the required communication range will be reduced with increasing the penetration rate of equipped vehicles. At the beginning, when only a few vehicles are equipped there is an increased probability for transmitting with a higher power to enable communications at all. But nevertheless also during the introduction phase vehicles will apply TPC and reduce the transmission power to the level needed for reliable communication. This is mandatory for efficient channel reuse and the link quality.

The typical communication range is expected to be below 500 m for rural areas. In suburban and urban areas, the communication range is usually lower. Considering typical values of traffic density, a proper value for an average communication range in rural and suburban areas is 300 m. Individually the required communication range is much lower, e.g. in the case of messaging between 2 consecutive vehicles driving on a motorway with 120 km/h, the safety distance and therefore the required communication range is about 60 m and the applied power level will be 3 dBm, which is the minimum level.

RSUs will provide a communication zone. The required size of the zone depends on the services, which are provided by the RSU, and on the environment. A typical value for rural areas is 600 m and for urban areas 400 m. With the RSU in the centre of the communication zone, the resultant communication range is 300 m for rural areas and 200 m for urban areas.

For the communication between vehicles and RSUs the required transmitted power can be asymmetric concerning uplink and downlink communications, because RSU will be deployed with directive antennas. This means that the average interference contribution from RSUs will be significantly lower than the e.i.r.p. value on its own would indicate

Based on the link budget calculations presented in part 1 of the present document, the following power levels should be considered for compatibility investigations.

Range (m)	1000	500	400	300	200	100	50	10
TP (dBm)	33	25	22	19	14	6	3	3

Considering TPC with a 30 dB range, the minimum power level is 3 dBm.

B.2 Technical fustification for spectrum

See part 1 of the present document for a detailed presentation.

B.3 Information on current version of relevant standards

Basic parameters and protocols for high-reliability road safety services are being developed as a co-operation between ETSI ERM-TG37, ISO TC204 WG16, C2C-CC and IEEE 802.11p (WAVE) [3].

The C2C-CC is working out specifications taking into account European regulations, infrastructures, driving behaviour and government policies. Standards will be produced for the communication system and for the road safety applications to ensure interoperability between all cars.

The ISO standards group TC204 WG16 is developing a set of standards (see ISO 21217 [7], ISO 21210 [5], ISO 21218 [8] and ISO 21215 [6]) for architecture, for bearers and for the networking protocols. This CALM architecture will link applications to an appropriate bearer of a set of bearers, depending on what each has to offer at a given time in a given situation. It is recognized that all bearers cannot support all applications, and that there will be circumstances which favour one over another.

Annex C:
Expected compatibility issues

C.1 Coexistence studies

Coexistence studies with existing radio services in the 5,9 GHz range are needed. Part 1 of the present document presents relevant European allocations in the neighbourhood of the spectrum proposed for allocation in the present document.

The ongoing studies in ECC include a full compatibility study (ITS versus other radio communication services/applications and other radio communication services/applications versus ITS) in the band from 5,875 GHz to 5,895 GHz and may need to be extended to frequencies up to 5,925 GHz. In addition, studies for frequencies in the ISM band were decided to only study the impact of ITS on other radio communication services/applications. Furthermore, the impact from ground radars below 5,850 GHz on ITS is also studied.

C.2 Current ITU allocations

In ITU-R, WP8A is responsible for ITS. There are some recommendations related to the 5 GHz band, mostly reflecting current RTTT DSRC allocations in Europe and Japan.

At the last World Radio Conference (WRC-03), the issue of a global allocation for ITS safety applications was brought up by Canada. This proposal received support from US and also from Europe. The proposal was withdrawn due to heavy opposition from some Asian countries.

C.3 Sharing issues

The road safety and traffic management applications considered in the present document require a more predictable sharing environment than is available inside spectrum where e.g. COTS WLAN or ISM equipment can tune directly. Major sharing issues and potential interference mitigation could be summarized in the following order as below:

- Minimum interference with currently allocated radio services.
- As far away from 5,8 GHz as possible to avoid interference with RTTT DSRC [9] since the devices ITS transmitter and RTTT OBU receiver will be located inside cars close to each other.
- Although the present document has its focus on roadside-to-vehicle communications, it also covers inter-vehicle communications. It must be noted that sharing with radar applications below 5,850 GHz might require an interference mitigation like DFS which is not compatible with highly mobile inter-vehicle applications. As a consequence, all ITS inter-vehicle communications might only be considered for the frequency range above 5,850 GHz.

NOTE: The proposal in clause 6.1 is in line with this consideration.

- By sharing the available bandwidth into different communication channels, a diversity factor could be integrated in the link budget which could also be used for interference mitigation.
- The integration of more directive antennas. One of the main impacts is given by radiation for high elevation angles (towards GSO satellite receivers). By focusing radiated energy horizontally towards infrastructure and vehicle interference towards will be decreased.
- ITS uses TPC as well as LBT. Especially, roadside-to-vehicle communications uses average communication ranges of much less than the maximum of 1 000 m, and TPC will have a large effect on total aggregated power levels.

Concerning interference to RTTT DSRC it is important to note that DSRC OBUs can cope with statistical random interference. However, systematic interference from IVC or RVC ITS could cause unacceptable interference and could also cause premature end-of-life of the OBUs due to OBU battery drain, if both kind of equipment are installed in the same vehicle. A potential solution under study to avoid this could be the integration of the RTTT OBU and ITS in one equipment device as specified in the CALM architecture (see ISO 21217 [7] and ISO 21218 [8]).

Possible interference mitigation factors (e.g. TPC, see clause B.1.2. of part 1) and channel access mechanisms will be investigated by ERM TG37 in the course of the sharing studies to be performed within CEPT ECC WGSE provided that results will indicate the need for such measures.

History

Document history		
V1.1.1	July 2006	Publication