European Radiocommunications Committee (ERC)
within the European Conference of Postal and Telecommunications Administrations (CEPT)

HARMONISATION OF FREQUENCY BANDS TO BE DESIGNATED FOR ROAD TRANSPORT INFORMATION SYSTEMS

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Reports are formally approved by, and issued in the name of, the Committee itself. In general the detailed preparation of Reports, and further work on the subject, will be done by Working Groups or Project Teams. Thus, any reference in the Reports to the ERC should be taken to include the whole framework of the ERC, including its Working Groups, Project Teams, etc.

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1. INTRODUCTION

Within Europe there is increasing interest in the development of a fully Integrated Road Transport Environment to improve all aspects of road transport. Many of the proposals require reliable communications links between roadside and vehicles and between vehicles, these may be realised using infra-red or radio based technology. For radio based systems, frequency allocations, harmonised throughout Europe, will be required.

This Report considers the spectrum requirements and other frequency management issues for various European Road Transport Information (RTI) applications.

2. BACKGROUND

In 1987, the Commission of the European Communities established a Community Research and Development programme: "Dedicated Road Infrastructure for Vehicle safety in Europe" (DRIVE), with the objectives of improving road safety transport efficiency and environmental quality. In September 1989, DRIVE's Systems Engineering and Consensus Formation Office (SECFO) submitted to CEPT a formal request for assistance and guidance on the availability of radio frequencies necessary to meet the requirements of RTI applications. A number of applications were identified:

- Automatic road toll collection
- Route guidance systems
- Vehicle or container identification
- Instant traffic information
- Parking management
- Collision avoidance by "co-operative driving" (i.e. interchange of information between vehicles and/or by use of on-vehicle radar systems)

An initial review (within DRIVE) of the frequency requirements for these applications suggested:

- a frequency within the range 1 GHz - 10 GHz to support immediate communications applications
- a higher frequency to supersede the first and to support a wider range of communications applications (e.g. 60 GHz)
- a further frequency to allow the introduction in the future of anti-collision radar systems (e.g. 80 GHz)

3. SELECTION OF FREQUENCY BANDS

The ERC has concentrated its research around the frequency bands suggested by SECFO, that is 1 GHz - 10 GHz, 60 GHz and 80 GHz.

3.1. Frequency Range 1 GHz - 10 GHz

A number of experimental and trial systems have been developed in this frequency range The most commonly used frequency bands are 2.4 GHz - 2.5 GHz and 5.725 GHz - 5.875 GHz, designated in the ITU Radio Regulations for Industrial Scientific and Medical (ISM) applications and the band 9.8 GHz - 10.0 GHz, allocated to the radiolocation service. Although most DRIVE applications do not fall into the category of ISM or radiolocation, these frequency bands are available in many CEPT countries for various low-power applications on a non-protected, non-interference basis.

The main advantage offered by frequencies below 10 GHz is that suitable technology is readily available, relatively simple, and cheap to manufacture, an important consideration to achieve public acceptance of initial RTI applications—road toll collection, parking control and road pricing. It is likely that most of the initial DRIVE applications will use "semi-passive" transponders (see Annex A) in vehicles. Although this technique overcomes the need for a vehicle mounted transmitter, choice of frequency band within the range 1 GHz - 10 GHz becomes critical as, due to increasing propagation attenuation with increasing frequency, the technique is more difficult to use at the higher frequencies.

After careful consideration, including a survey of frequency availability in CEPT countries, and noting the considerable demand for other services in the 1 GHz - 3 GHz band, 5.795 GHz - 5.805 GHz was chosen as the band that most closely met the DRIVE requirements of:

— availability throughout CEPT
— as low a frequency as possible below 10 GHz
— available as soon as possible to meet initial requirements

This 10 MHz band will be insufficient to meet the requirements of multi-lane motorway junctions. An extension band of 10 MHz (5.805 GHz - 5.815 GHz) may be made available on a national basis.

3.2. **A higher frequency to support a wider range of communications requirements**

Future RTI applications are less well defined but will certainly involve interchange of information between vehicles to enable "co-operative driving", for example, vehicle control for safe lane changing, highway merging and rapid warning of accidents ahead.

Such applications will require higher data rates (perhaps up to 20 Mbit/s), greater range (300 m) and involve as many as a hundred vehicles in a congested area. Much of the current work has focused on the 60 GHz region, where the propagation characteristics due to Oxygen absorption can assist overall system design.

CEPT has a long term objective to harmonise use of the millimetre-wave spectrum (between 30 GHz to 300 GHz). Within this range, it was recognised that development of the 54.25 GHz - 66 GHz band required urgent action on a provisional basis, and a Recommendation for use of this frequency range (T/R 22-03 E) was approved by the ERC (Athens 1990). This Recommendation takes into account the needs of RTI applications and designates a 1 GHz sub-band (63 GHz - 64 GHz), which was considered sufficient to meet the estimated requirements.

3.3. **A frequency band for vehicle radar**

Vehicle radar can be used for "anti-collision" and "cruise control" purposes to measure the relative speed and distance between adjacent vehicles in the same lane, a range of up to 200 metres is required. Experimental systems have been developed in the 10, 17, 24, 35 and 80 GHz bands. Information from DRIVE and European manufacturers in the automobile sector suggests that the 80 GHz band offers the advantage of small antenna size and range resolution. The frequency band 76 GHz - 81 GHz is allocated internationally to the radiolocation service on a primary basis and to the amateur and amateur satellite service on a secondary basis. Within CEPT countries very little use is made at present of this band, so the band 76 GHz - 77 GHz could be made available for vehicle radars. Technical evolution of this type of application could increase or decrease this bandwidth. If an increase proves necessary, the provisions of footnote RR 912 would require compatibility studies.

4. **OTHER TECHNICAL PARAMETERS**

A table summarising the radio link parameters for typical applications is given in Annex B.

Those for 60 GHz and 80 GHz are based on best estimates from the current (early) stage of development. For 5.8 GHz development is more advanced and at a critical stage; system designers require urgently guidance from frequency managers on the maximum e.i.r.p. and bandwidth to be permitted. The e.i.r.p. of 2 watt (3 dBW) is based on link budget calculations for a semi-passive transponder system. As mentioned in 3.1. above, a bandwidth of 10 MHz will be available with an additional 10 MHz to meet the requirements of multi-lane junctions; this will be shared with other systems and services, e.g. short range systems, certain radiolocation systems, the fixed and fixed-satellite services and ISM.

5. FREQUENCY MANAGEMENT ISSUES INCLUDING SHARING

In future years, it is expected that the majority of road vehicles will be equipped with RTI equipment and there will be widespread use of roadside interrogators/beacons. It would be difficult and undesirable for Administrations to undertake frequency assignment or co-ordination for each roadside or vehicle installation.

The frequency bands recommended for the various RTI applications have been selected on the basis that there is a high degree of compatibility with the existing services, so avoiding the need for exclusive bands or complex frequency planning and co-ordination.

The frequency band 5.725 GHz - 5.850 GHz is allocated in Region 1 to the fixed-satellite (Earth-to-space) and radiolocation services on a primary basis and the amateur and amateur-satellite (5.830 GHz - 5.850 GHz) service on a secondary basis. Footnotes provide additional allocations in some countries to other services. Footnote RR 806 designates the band 5.725 GHz - 5.875 GHz for ISM applications; radiocommunications services operating within this band must accept harmful interference from ISM equipment.

For the 63 GHz - 64 GHz and 76 GHz - 81 GHz bands, the short ranges, directive antennas, etc. suggest there is little likelihood of incompatibility with the other services sharing these bands.

Designers of RTI systems should take into account that the frequency bands designated by CEPT for RTI applications are non-exclusive and should develop intelligent systems with robust signalling protocols capable of providing satisfactory operation in these shared bands.

6. TIMESCALES

Initial RTI applications (road toll collection, etc.) in the 5.8 GHz band can be expected to start operation, in some countries, within the next two to three years. Assuming DRIVE achieve a standard protocol for signalling between vehicle and roadside and develop a method for international charging, international road toll collection systems could be expected within five to seven years. It is probable that early route guidance systems will take advantage of the technology and use the 5.8 GHz band.

By the year 2000, 60 GHz systems will begin to supersede older 5.8 GHz systems, some of the technology developed for the short range fixed link bands at 58 GHz could be adapted for RTI applications. It will be considerably longer (perhaps 20 years) before vehicle to vehicle communications systems can be exploited fully, as "co-operative" driving techniques work only when all vehicles are equipped; this will probably require mandatory legislation in all European countries.

Vehicle radar systems at 76 GHz can work independently in any vehicle. Commercially available systems can be expected within 5 years as optional extras on luxury cars.

7. CONCLUSION

This report has examined the needs of Road Traffic Information (RTI) systems and concludes that three frequency bands are required to meet the short and long term needs of RTI. Suitable frequency bands have been identified; these are available immediately and, as far as can be determined, RTI systems are compatible with existing services such that exclusive bands are not required.

ANNEX A

TRANSPONDER TECHNOLOGY

Passive Transponder

A passive transponder requires no on-board power source; it is powered by the incident signal from the interrogator beacon and responds with a fixed message by modulating and reflecting the incident signal.

Active Transponder

An active transponder is an independent, self-powered transceiver, generating its own carrier signal, perhaps on a different frequency to the interrogator.

Semi-Passive Transponder

Combines the characteristics of active and passive transponders. Carries its own power source to maintain a volatile memory and, in some cases, an amplifier in the receiver/modulator circuit. Does not generate an independent radio carrier.

ANNEX B

SUMMARY OF RADIO LINK PARAMETERS FOR TYPICAL APPLICATIONS

Parameter	Initial Systems	Future Systems	Radar Systems
Frequency (GHz)	5.795-5.805	63-64	76-77
e.i.r.p. (dBW)	3.0	3.0-16.0	16.0-20.0
Antenna gain (dBi)	10-15	10-30	30-35
Range (metres)	5-30	300	200
Channel-bandwidth Total	5 MHz 10 MHz*	5-20 MHz 1 GHz	100 MHz FM 500 MHz pulse 1 GHz
Data rate (Mbit/s)	1-3	1-20	
Modulation	FSK PSK ASK/AM	FSK PSK AM, FM	FM Pulse

Application

Initial systems: Vehicle to road, toll collection, road pricing, parking control, route guidance

Future systems: Supersede initial systems, vehicle to vehicle, co-operative driving, lane changing, "instant" advance incident warning

Radar systems: On-vehicle anti-collision radar, cruise control

* An additional 10 MHz (5.805 GHz - 5.815 GHz) may be made available on a national basis to meet specific local requirements—see section 3.1 of the Report