



Technical Report

**Electromagnetic compatibility and
Radio spectrum Matters (ERM);
System Reference document (SRdoc);
Technical characteristics of Radio equipment
to be used in the 76 GHz to 77 GHz band;
Short-Range Radar to be fitted
on fixed transport infrastructure**

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Foreword

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

EC Decision 2011-829-EU [i.9] obliges EU Member States to allow the use of the 76 GHz to 77 GHz band for Road Transport and Telematics for *terrestrial vehicles and infrastructure systems*.

This EC Decision is subject to an update process. CEPT Report 44 [i.10] is the recommendation from CEPT for the 5th update cycle. In this it is recommended to broaden the category of Road Transport and Traffic Telematics (RTTT) to Transport and Traffic Telematics (TTT), and to change the usage restriction on 76 GHz to 77 GHz band to *ground based vehicle and infrastructure systems only*.

The draft revised Decision [i.11] indicates that these recommendations are being adopted.

Accordingly, the present document describes fixed infrastructure radar systems in a range of transport applications.

A previously published ETSI System Reference Document, TR 102 704 [i.7], discusses the use of 76 GHz to 77 GHz band by radars mounted on ground based vehicles other than automobiles.

The purpose of the present document is to provide details of how fixed infrastructure radar are used within the transportation sector, and to indicate the parameters under which these systems operate.

Modal verbs terminology

In the present document "**shall**", "**shall not**", "**should**", "**should not**", "**may**", "**may not**", "**need**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the [ETSI Drafting Rules](#) (Verbal forms for the expression of provisions).

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Executive summary

The present document provides information about fixed surveillance radar installations in the 76 GHz to 77 GHz band.

The majority of the systems described here are high value infrastructure systems serving functions of safety and efficiency in the transport field. Typical uses are for surveillance of critical highway situations such as tunnels and large road intersections. There is a requirement in the EU for Automatic Incident Detection in road tunnels which have a control room and are 500 m or longer [i.1].

Other users of the 76 GHz to 77 GHz band include vehicle radars and the Radio Astronomy Service. The important sharing scenarios are therefore a large number of vehicle radars with a small number of fixed radars and with the RAS conducting measurements from 8 sites in Europe.

The 76 GHz to 77 GHz band is designated for both fixed and vehicle radars by 2011-829-EU (the EC Decision on Short Range Devices) [i.9]. Currently there is a harmonised standard for vehicle radars, EN 301 091-1 [i.8], but fixed radars are outside its scope. The fixed radars described here operate with the same signal parameters as vehicle radars - they are in fact compliant with the technical requirements of EN 301 091-1 [i.8].

It should be noted that the fixed radars described do not constitute a new proposal. They represent an established application with a significant installed base. Systems are currently being installed in many European countries (Annex B), but by their nature as high capital cost infrastructure systems they cannot be expected to become massively deployed items.

The present document also examines the sharing scenarios. An acceptable arrangement with the RAS is a small exclusion zone around each millimetre wave observatory site (Annex E). An initial study shows that probability of a scanning infrastructure radar interfering with a vehicular radar is even less than that of a vehicular radar interfering with another vehicular radar (Annex D). The purposes of the present document include:

- 1) To provide information to CEPT, EC and other bodies to assist studies and regulatory decisions.
- 2) To pave the way for ETSI to develop a harmonised standard for fixed surveillance radars.

The present document concentrates on applications for surveillance radars in the transport field. The proponents of the SRdoc also note that there are applications in other fields and these are described in clause B.3.

Introduction

The present document has been developed to support the co-operation between ETSI and the Electronic Communications Committee (ECC) of the European Conference of Post and Telecommunications Administrations (CEPT).

The European Commission Decision on harmonisation of the radio spectrum for use by short-range devices 2006/771/EC sets out the harmonised frequency bands as well as the technical usage conditions under which SRDs can be used across Europe. Last updated in December 2011 under EC Decision 2011/829/EU [i.9], the decision sets the usage scope for this band as "terrestrial vehicle and infrastructure systems".

The 76 GHz RTTT Standard EN 301 091-1 [i.8] defines the technical characteristics and test methods for radar equipment operating in the 76 GHz to 77 GHz band. Early versions of EN 301 091-1 [i.8] define the scope as covering both fixed radar installations, and mobile. Subsequent versions of EN 301 091-1 [i.8] have limited the scope to road vehicles only. Other than the definition of the scope, the fixed radar systems presented are fully compliant with the latest versions of EN 301 091-1 [i.8].

The 76 GHz to 77 GHz band is highly versatile and can be used also for safety relevant radar applications which operate either as part of a fixed transport installation, or on a mobile vehicle. These safety related fixed transport installations are the subject of the present document.

The main benefits of using the 76 GHz to 77 GHz frequency band for these applications are that overall radar sensor package sizes can be made of a reasonable size without overly large or cumbersome antenna. These are suitable for roadside installation. With high operating frequency, high resolution range measurements are possible. In addition componentry is readily available in this band. These advantages are further discussed within.

1 Scope

The present document describes the application of fixed transport surveillance radar systems in the 76 GHz to 77 GHz band. Short Range Radars operating in this band are used in a variety of applications, the majority of which are safety related.

The present document includes in particular:

- market information for applications apart from road vehicles;
- technical information regarding the typical radar installations;
- regulatory issues and interference studies whilst considering other band users.

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 referenced 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>.

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2.1 Normative references

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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. For non-specific references, the latest version of the referenced document (including any amendments) applies.

- [i.1] L167/39: "Directive 2004/54/EC of the European Parliament and of the Council of 29 April 2004 on minimum safety requirements for tunnels in the Trans-European Road Network".
- [i.2] WN 96W0000071: "The Impact of Rapid Incident Detection on Freeway Accident Fatalities".
- [i.3] Rail Safety and Standards Board: "Half-year safety performance report 2012/13".
- [i.4] Network Rail: "Strategic Business Plan for England & Wales January 2013".
- [i.5] European Railway Agency: "Railway safety performance in the European Union 2012".
- [i.6] European Commission: "Mobility and Transport, Road Safety, Level Crossings".

NOTE: Available at: http://ec.europa.eu/transport/road_safety/topics/infrastructure/level_crossing/index_en.htm.

- [i.7] ETSI TR 102 704 (V1.2.1) (2010-12): "Electromagnetic compatibility and Radio spectrum Matters (ERM); System Reference Document; Short Range Devices (SRD); Radar sensors for non-automotive; ground based vehicular applications in the 76 GHz to 77 GHz frequency range".

- [i.8] ETSI EN 301 091-1 (V1.3.3): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Short Range Devices; Road Transport and Traffic Telematics (RTTT); Radar equipment operating in the 76 GHz to 77 GHz range; Part 1: Technical characteristics and test methods for radar equipment operating in the 76 GHz to 77 GHz range".
- [i.9] EC Decision 2011-829-EU: Commission Implementing Decision of 8 December 2011 amending Decision 2006/771/EC on harmonisation of the radio spectrum for use by short-range devices.
- [i.10] CEPT Report 44 (11/03/2103): In response to the EC Permanent Mandate on the "Annual update of the technical annex of the Commission Decision on the technical harmonisation of radio spectrum for use by short range devices".
- [i.11] RSCOM13-05 (6th March 2013). European Commission Communications Networks Content & Technology Directorate-General. Radio Spectrum Committee: Draft Implementing Decision for the coordinated revision of Decision 2006/771/EC on SRD and the repeal of Decision 2005/928/EC on the 169 MHz band.
- [i.12] CEPT/ERC/Recommendation 70-03: "Relating to the use of Short Range Devices (SRD)". Annexes 4 and 5.
- [i.13] ERC Report 25: "The European Table of Frequency Allocations and Applications in the Frequency Range 8.3 kHz to 3000 GHz (ECA TABLE)". Approved February 2013.
- [i.14] MOSARIM: "MOre Safety for All by Radar Interference Mitigation".
- NOTE: Available at: http://ec.europa.eu/information_society/activities/esafety/doc/rttd_projects/fact_sheets_fp7/mosarim.pdf.
- [i.15] UK Highways Agency: Results published in March 2011 in the UK Highways Agency's three-year safety report into the pilot Managed Motorway scheme on the M42.
- NOTE: Available at: <http://www.highways.gov.uk/our-road-network/managing-our-roads/improving-our-network/managed-motorways/>.
- [i.16] ETSI EN 301 783 (all parts): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Land Mobile Service; Commercially available amateur radio equipment".
- [i.17] ETSI EN 302 264 (all parts): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Short Range Devices; Road Transport and Traffic Telematics (RTTT); Short Range Radar equipment operating in the 77 GHz to 81 GHz band".
- [i.18] ETSI EN 302 372 (all parts): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Short Range Devices (SRD) ;Equipment for Detection and Movement; Tanks Level Probing Radar (TLPR) operating in the frequency bands 5,8 GHz, 10 GHz, 25 GHz, 61 GHz and 77 GHz".
- [i.19] ETSI EN 302 729 (all parts): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Short Range Devices (SRD); Level Probing Radar (LPR) equipment operating in the frequency ranges 6 GHz to 8,5 GHz, 24,05 GHz to 26,5 GHz, 57 GHz to 64 GHz, 75 GHz to 85 GHz".
- [i.20] ECC/DEC/(04)03: "ECC Decision of 19 March 2004 on the frequency band 77-81 GHz to be designated for the use of Automotive Short Range Radars".
- [i.21] ECC/DEC/(11)02: "ECC Decision of 11 March 2011 on industrial Level Probing Radars (LPR) operating in frequency bands 6 - 8.5 GHz, 24.05 - 26.5 GHz, 57 - 64 GHz and 75 - 85 GHz".
- [i.22] ERC/REC 74-01: "Unwanted Emissions in the Spurious Domain".
- [i.23] Recommendation ITU-R RA.769-2: "Protection criteria used for radio astronomical measurements".
- [i.24] Recommendation ITU-R P.452-1: "Prediction procedure for the evaluation of microwave interference between stations on the surface of the Earth at frequencies above about 0.7 GHz".
- [i.25] Recommendation ITU-R P.525: "Calculation of free-space attenuation".

3 Definitions, symbols and abbreviations

3.1 Definitions

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

all lane running: permanent use of the hard shoulder or emergency lane as a running lane

antenna boresight: optical axis of a directional antenna, along which the peak antenna gain is found

duty cycle: ratio of the area of the beam (measured at its 3 dB point) to the total area scanned by the antenna (as measured at its 3 dB point)

managed motorways: controlled use of the hard shoulder as a running lane during periods of high vehicle flow or incidents

operating frequency: nominal frequency at which the equipment is operated

radome: external protective cover which is independent of the associated antenna, and which may contribute to the overall performance of the antenna

3.2 Symbols

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

| | |
|------------|---|
| Δf | frequency shift between any two frequency steps |
| F | frequency |
| R | distance to target |
| R_x | received signal |
| T | frequency step repetition frequency |
| T_x | transmitted signal |

3.3 Abbreviations

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

| | |
|---------|---|
| AID | Automatic Incident Detection |
| CCTV | Closed Circuit TeleVision |
| CFAR | Constant False Alarm Rate |
| CRAF | Committee on Radio Astronomy Frequencies |
| e.i.r.p | effective isotropic radiated power |
| EC | European Commission |
| ECC | Electronic Communications Committee |
| FM | Frequency Modulation |
| FMCW | Frequency Modulated Carrier Wave |
| IRAM | Institut de Radioastronomie Millimétrique |
| LPR | Level Probing Radar |
| PTZ | Pan, Tilt, Zoom |
| RAS | Radio Astronomy Service |
| RF | Radio Frequency |
| RPU | Remote Processing Unit |
| RR | Radio Regulations |
| RSSB | Rail Safety and Standards Board |
| RTTT | Road Transport and Traffic Telematics |
| SEAMCAT | Spectrum Engineering Advanced Monte Carlo Analysis Tool |
| TEN | Trans-European Transport Network |

| | |
|-------|---------------------------------------|
| TEN-T | Trans-European Transport Network |
| TLPR | Tanks Level Probing Radar |
| TTT | Transport and Traffic Telematics |
| WRC | World Radio communications Conference |

4 Comments on the System Reference Document

No ETSI members raised any comments.

5 Fixed Transport Infrastructure Radar

This clause contains a brief summary of infrastructure radar and its applications. More comprehensive information together with example installations can be found in Annex B.

5.1 System Description

Fixed Radar systems provide an Automatic Incident Detection capability, for use on motorways and other strategic roads, bridges and tunnels. By continually measuring and tracking vehicles, people and debris using high frequency radar the system is able to generate incident alerts, whilst maintaining extremely low nuisance alarm rates.

5.2 Use Cases and Deployment Scenarios

5.2.1 Surveillance radar for traffic incident detection and prevention

Wide area surveillance of roads, to detect events that are highly likely to lead to incidents, is a valuable way of improving the safety of European road networks. These might include early detection of stopped vehicles, reversing vehicles, personnel or animals on a road carriageway, debris on a carriageway due to a lost load. Europe's major highways are increasingly congested; managed motorways are becoming more prevalent so extra capacity from emergency lanes without the associated costs of extra civil works; reduced Carbon to provide extra road network capacity; these roads do need a rapid detection system though to alert approaching driver in fast moving traffic to a stranded vehicle in a live traffic lane, particularly at night time or in poor visibility.

5.2.2 Surveillance radar for traffic enforcement and safety

Enforcing unsafe behaviour of vehicles, unsafe close following of the vehicle ahead, unsafe overtaking or crossing of the central white lines, illegal behaviour at yellow box junctions leading to congestion as busy intersections become congested, enforcing and thereby discouraging dangerous driving manoeuvres such as illegal U-Turns, enforcement where dangerous driving behaviour can lead to loss of life around intersections with other modes of transport, for example, at railway crossings.

5.2.3 Road-Railway Crossings

Two types of surveillance radar systems are proposed for increasing safety at road-railway crossings, also known as level crossings.

5.2.3.1 Railway network based

Railway based radars function as obstacle detectors for use only when the crossing is operated as a railway. Generally they are fixed rather than scanning beam and oriented so as to illuminate the crossing area and the railway track. These would fall under Annex 4 of Rec 70-03 [i.12]. ETSI intends to introduce a new harmonised standard EN 301 091-3 to cover this application.

5.2.3.2 Road network based

Fixed radars can provide a more extensive surveillance of the crossing area and detect illegal or dangerous behaviour by vehicles, for instance turning along the railway track, failing to stop for the warning lights, driving round the barriers. More details of such systems is given in clause B.2.2.

5.2.4 Airport Ground Movements

Fixed radars are used for monitoring ground movements at airports and landing strips, for the purposes of Air Traffic Control and for security. More details of such systems are given in clause B.2.3.

5.2.5 Non-Transport Applications

Applications outside the field of transport are also possible and currently permitted in some countries, such as the UK. Some of these are described in clause B.3.

6 Market Size and Societal Benefits

This clause is a brief summary. Comprehensive market information for existing and projected installations is given in clause B.2.

6.1 Automatic Incident Detection

Managed motorway programs are currently in operation within the UK, Sweden, Netherlands and Germany, each maintaining between 200 km to 300 km. Casualties per billion vehicle miles travelled have reduced by just under two-thirds (61 %) since hard shoulder running was introduced [i.15]. Managed motorways offer increased capacity, at a fraction of the cost, and can be delivered in a much shorter timeframe.

Fatal Incidents within tunnels in particular have raised concerns about current safety systems, and within EC law, it is mandatory in all tunnels longer than 500 m to install automatic incident detection and/or fire detection [i.1].

The Trans-European Transport Network (TEN- T) is set to encompass 90 000 km of motorway and high-quality roads by 2020 and the EU will eventually have a role in the safety management of these roads.

6.2 Traffic Enforcement

Enforcement, leading to behaviour change of drivers and pedestrians, is an important part of the regulators' strategy to reduce the number of fatalities at level crossings and other intersections. Fixed radar systems, tracking vehicles as they drive towards the crossing after red warning lights have been illuminated, are an important tool to improve safety. Some 200 initial sites have been identified by Network Rail in the UK as requiring railway crossing enforcement systems.

7 Technical information

7.1 Detailed technical description

The radar systems described in the present document use a continuous transmission with frequency modulation. The operating principle is described in detail in Annex A.

Annex B shows a number of existing installations.

The systems are compliant with the technical parameters of EN 301 091-1 [i.8]. Further technical information is also given in Annexes C, D and E.

7.2 Technical parameters and implications on spectrum

Table 1 lists the typical parameters of a mechanically scanned infrastructure radar system.

See clauses 7.2.2 and 7.2.3 for further information.

Table 1: Summary of typical technical parameters

| | |
|---|---|
| Frequency Range | 76,2 GHz to 76,8 GHz |
| Range of Sensor | 500 m |
| Field of View coverage | full coverage (for scanning systems) |
| Peak Power | 37,5 dBm |
| Average Power | 15 dBm (according to the formula in clause 7.2.3.2. of EN 301 091-1 (V1.3.3) [i.8]) |
| Occupied RF Bandwidth | 600 MHz |
| Rotation and transmission rate (scanning systems) | nominal 2 rps, through 360 degrees 1 000 ms sweep time leading to 900 measurements per second (450 per rotation) |
| Beam width in azimuth | 2 degrees |
| Duty Cycle | 0,5 % |
| Mounting Height | Typically 5 m above ground level |
| Deployment of infrastructure radar | Typical separation of 700 m to 1 000 m |

7.2.1 Status of technical parameters

7.2.1.1 Current ITU and European Common Allocations

The following table is reproduced from ERC Report 25, February 2013 [i.13].

Table 2: 76 GHz to 77 GHz entry in European Common Allocation table

| RR Region 1 Allocation and RR footnotes applicable to CEPT | European Common Allocation | ECC/ERC harmonisation | Applications | Standard | Notes |
|--|----------------------------|---|----------------------------------|--|--|
| 76 GHz to 77,5 GHz | | | | | |
| RADIO ASTRONOMY | RADIO ASTRONOMY | | Amateur | EN 301 783 [i.16] | |
| RADIOLOCATION | RADIOLOCATION | | Amateur Satellite | | |
| Amateur | Amateur | ECC/DEC/(04)03 [i.20] | SRR | | |
| Amateur-satellite | Amateur-satellite | | Radiolocation (civil) | EN 302 264 [i.17] | |
| Space research (S/E) | Space research (S/E) | | Radio astronomy | | Continuum and spectral line observations |
| 5.149 | 5.149 EU2 | ERC/REC 70-03 [i.12] ECC/DEC/(11)02 [i.21] | Radio determination applications | EN 302 372 [i.18] EN 302 729 [i.19] | Within the band 75 GHz to 85 GHz for TLPR and LPR applications |
| | | ERC/REC 70-03 [i.12] | RTTT | EN 301 091-1 [i.8] | Within the band 76 GHz to 77 GHz Radar. Road Transport and Traffic Telematic |
| | | | Railway applications | EN 301 091-1 [i.8] | Obstruction/vehicle detection at level crossings |