

**Electromagnetic compatibility
and Radio spectrum Matters (ERM);
SRD radar equipment using
Wideband Low Activity Mode (WLAM) and operating in the
frequency range from 24,05 GHz to 24,50 GHz;
System Reference Document**



Reference

RTR/ERM-TGSRR-058

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Foreword

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

Executive summary

The European Union's eSafety Initiative in 2003 established the goal to reduce the number of road fatalities by 50 % up to the year 2010. According to some accident studies referred to in TR 102 664 [i.9], rear-end collisions dominate in collision statistics.

The 2nd Mandate of the European Commission on SRR [i.4] calls for alternative regulatory options for short range radars. The proposed regulation is based on the existing 24 GHz NB radar operating in the 24,05 GHz to 24,25 GHz band and is related to a supplementary mode for an extension band which ranges from 24,25 GHz to 24,50 GHz and operates with a low-activity factor. In certain driving situations, this supplementary mode will be activated. It extends the usable radar bandwidth from 200 MHz (ISM Mode) to 450 MHz (WLAM Mode).

WLAM is seen as being complementary to existing regulations for automotive radar applications. This regulatory solution does not compete with long range solutions which can be addressed by 77 GHz to 79 GHz. The addition of the WLAM extension mode to the present 24 GHz NB radars will minimize the investment required. The present document describes the need for an improvement of the existing 24 GHz NB automotive radars. The following information is important to note:

- 1) The 24 GHz NB technology has been successfully deployed since it covers most of the short/mid-range driving assistance and safety features required to the front and rear of the car, based on a 200 MHz bandwidth.
- 2) Many car-makers have invested in the 24 GHz NB technology which is in line with the frequency allocation strategy defined by the CEPT and European Commission.
- 3) The WLAM mode will improve the 24 GHz NB technology in specific driving situations, where a larger bandwidth is required to discriminate specific targets such as pedestrians in parking lots or cities.
- 4) The WLAM mode is expected to comply with the protection of the passive services between 23,6 GHz to 24 GHz.
- 5) The WLAM mode is not seen to impact the fixed services implemented between 24,5 GHz and 26,5 GHz.
- 6) The WLAM mode is using a bandwidth also designated for SAP/SAB temporary applications, which are unidirectional fixed links.
- 7) The radar technology is available. A short term safety benefit can be achieved at a limited add-on development cost.

Add-on system cost due of additional sensors for front radar WLAM activation and pedestrian recognition and time for the implementation of these technologies are not regarded in the present document.

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) for internal reference within ETSI.

The European Commission has issued a new Mandate [i.4] to the ECC related to automotive Short Range Radars (SRR), whose purpose is divided in two different parts. Part 1 of the Mandate is linked to the fundamental review as defined in EC Decision 2005/50/EC [i.1] related to the harmonization of the 24 GHz range radio spectrum band for the time-limited use by automotive short-range radar equipment in the community.

According to Part 2, this mandate also requires studies regarding alternative solutions for radar-based road-safety applications. An open question raised is on:

"CEPT is mandated to, where any alternative bands are to be considered for automotive short-range radar systems, propose appropriate technical and regulatory measures to ensure the protection of existing radio services in or near any such bands."

ECC WGFM has requested ETSI TC ERM to create an ETSI System Reference document on WLAM. ERM#39 adopted a new work item for the creation of such an ETSI System Reference document. The present document is intended to deliver the technical characteristics necessary to describe the spectrum needs, the expected usage scenario and technical performance and implementation aspects for 24 GHz WLAM equipment. In addition, related market information is provided.

1 Scope

The present document provides information on short range device equipment using the Wideband Low Activity Mode (WLAM) and operating in the frequency range from 24,05 GHz to 24,50 GHz noting that the WLAM mode is activated in certain use cases. The primary application focus is pedestrian detection and protection.

The present document includes the necessary information to support the co-operation between ETSI and the ECC including:

- market information;
- technical information;
- regulatory issues.

2 References

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the reference document (including any amendments) applies.

Referenced documents which are not found to be publicly available in the expected location might be found at <http://docbox.etsi.org/Reference>.

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2.1 Normative references

The following referenced documents are necessary for the application of the present document.

Not applicable.

2.2 Informative references

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

- [i.1] Commission Directive 2005/50/EC of 11 August 2005 on the reclassification of hip, knee and shoulder joint replacements in the framework of Council Directive 93/42/EEC concerning medical devices.

NOTE: Notified under document number C(2005)34.

- [i.2] CEPT ECC/DEC/(04)10: ECC Decision of 12 November 2004 on the frequency bands to be designated for the temporary introduction of Automotive Short Range Radars (SRR) (2004/545/EC) and (2005/50/EC) amended 5 September 2007.
- [i.3] CEPT 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.4] 2nd Mandate of the European Commission on SRR (document RSCOM08-81 Final of 7 November 2008).
- [i.5] CEPT ERC Report 36: "Sharing between the Fixed Service and the Radio Astronomy Service in the Frequency Range 3.4 GHz - 105 GHz".

- [i.6] Commission Decision 2004/545/EC of 8 July 2004 on the harmonisation of radio spectrum in the 79 GHz range for the use of automotive short-range radar equipment in the Community (notified under document number C(2004) 2591)(Text with EEA relevance).

NOTE: Notified under document number C(2004)2591.

- [i.7] CEPT/ERC/Recommendation 74-01E: "Unwanted Emissions in the Spurious Domain".
- [i.8] CEPT/ERC/Recommendation 70-03: "Relating to the use of Short Range Devices (SRD)".
- [i.9] ETSI TR 102 664 (V1.2.1): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Road Transport and Traffic Telematics (RTTT); Short range radar to be used in the 24 GHz to 27,5 GHz band; System Reference document".
- [i.10] Commission Decision 2009/381/EC of 13 May 2009 amending Decision 2006/771/EC on harmonisation of the radio spectrum for use by short-range devices (Text with EEA relevance).

NOTE: Notified under document number C(2009) 3710).

- [i.11] ECC Report 23: "Compatibility of automotive collision warning Short Range Radar operating at 24 GHz with FS, EESS and Radio Astronomy" .
- [i.12] CEPT/ECC Report 002: "Harmonisation of the Frequency usage within the additional frequency band of 2500-2690 MHz to be made available for IMT-2000/UMTS systems in Europe".
- [i.13] Regulation (EC) No 661/2009 of the European Parliament and of the council of 13 July 2009 concerning type-approval requirements for the general safety of motor vehicles, their trailers and systems, components and separate technical units intended therefor.
- [i.14] INSEE (Institut national de la statistique et des études économiques) website: "Statistics on accidents with pedestrians in France in 2008".

NOTE: <http://www.insee.fr/fr/default.asp>.

- [i.15] INSEE (Institut national de la statistique et des études économiques) website: "Overview of car accidents in France in 2008".

NOTE: <http://www.insee.fr/fr/default.asp>.

- [i.16] INSEE (Institut national de la statistique et des études économiques) Première N 1129-March 2007. Statistics of the distance between employees home and work in France. Website.

NOTE: http://www.insee.fr/fr/themes/document.asp?reg_id=0&ref_id=ip1129.

- [i.17] ETSI EN 300 440 (all parts): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Short range devices; Radio equipment to be used in the 1 GHz to 40 GHz frequency range".
- [i.18] ETSI EN 302 858: "Electromagnetic compatibility and Radio spectrum Matters (ERM); Road Transport and Traffic Telematics (RTTT); Short range radar equipment operating in the 24,05 GHz to 24,25 GHz frequency range for automotive application; Part 1: Technical characteristics and test methods".
- [i.19] ETSI EN 302 288-2 (V1.3.2): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Short Range Devices; Road Transport and Traffic Telematics (RTTT); Short range radar equipment operating in the 24 GHz range; Part 2: Harmonized EN covering the essential requirements of article 3.2 of the R&TTE Directive ".
- [i.20] ITU Draft report SM.2153: "Technical and operating parameters and spectrum use for short range radiocommunication devices".
- [i.21] Commission Decision 2006/771/EX of 9 November 2006 on harmonisation of the radio spectrum for use by short-range devices.
- [i.22] ERC/REC 25-10: "Frequency Ranges for the use of temporary terrestrial audio and video SAP/SAB LINKS".

- [i.23] Commission Decision 2008/411/EC of 21 May 2008 on the harmonisation of the 3 400-3 800 MHz frequency band for terrestrial systems capable of providing electronic communications services in the Community.
- [i.24] Draft CEPT Brief on AI 1.5.
- [i.25] Radio Frequency Devices, Section 15.245.
- [i.26] RSS-210: "Low-power Licence-exempt Radiocommunication Devices (All Frequency Bands): Category I Equipment".
- [i.27] CEPT/ECC-PT FM45: "Digital Broadcasting Issues".

3 Definitions, symbols and abbreviations

3.1 Definitions

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

activity factor: actual on-the-air time divided by active session time or actual on-the-air emission time within a given time window

bandwidth: range of frequencies, expressed in Hertz (Hz), that can pass over a given transmission channel

duty cycle: ratio of the total on time of the "message" to the total off-time in any one hour period

frequency allocation (of a frequency band): entry in the Table of Frequency Allocations of a given frequency band for the purpose of its use by one or more terrestrial or space *radiocommunication services* or the *radio astronomy service* under specified conditions

Industrial Scientific and Medical bands (ISM): frequency bands in which non-radio RF emissions can be allocated

Narrowband (NB): classification for the spectral width of a transmission system

occupied bandwidth: bandwidth of an emission defined as 10 dB bandwidth of the power spectral density

Power Spectral Density (dBm/Hz) (PSD): ratio of the amount of power to the used radio measurement bandwidth

NOTE: It is expressed in units of dBm/Hz or as a power in unit dBm with respect to the used bandwidth. In case of measurement with a spectrum analyser the measurement bandwidth is equal to the RBW.

resolution: degree to which a measurement can be determined is called the resolution of the measurement

separation: capability to discriminate two different events (e.g. two frequencies in spectrum or two targets over range)

Spread Spectrum techniques: methods by which [electromagnetic energy](#) generated in a particular [bandwidth](#) is deliberately spread in the [frequency domain](#), resulting in a [signal](#) with a wider bandwidth

ultra wideband: classification for the spectral width of a transmission system

wideband: classification for the spectral width of a transmission system

3.2 Symbols

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

ΔR	Range separation
dBm	dB relative to one milliwatt
f	Frequency
P	Power
R	Distance
td	tone duration

T Time

3.3 Abbreviations

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

ACAS	Automotive Collision Avoidance System
ACC	Automotive Cruise Control
APPS	Active braking for Pedestrian Protection Support
BSD	Blind Spot Detection
CTA	Cross-Traffic Alert (Rear)
CW	Continuous Wave
e.i.r.p.	equivalent isotropically radiated power
EBU	European Broadcasting Union
ECC	Electronic Communications Committee
ECU	Electronic Control Unit
ESP	Electronic Stability Program
EuroNCAP	European New Car Assessment Program
FCC	Federal Communications Commission
FCW	Forward Collision Warning
FMCW	Frequency Modulated Continuous Wave
GaAs	Gallium Arsenide
INSEE	Institut National de la Statistique et des Etudes Economiques (France)
ISM	Industrial Scientific, Medical
LCA	Lane Change Assist
LRR	Long Range Radar
MRR	Mid Range Radar
MU/y	Million units per year
n/a	not applicable
NB	Narrow Band
PMSE	Programme Making Special Events
PROD	production
RF	Radio Frequency
SAB	Service Ancillary to Broadcasting
SAP	Services Ancillary to Production
SiGe	Silicon Germanium
SRD	Short Range Device
SRR	Short Range Radar
UWB	UltraWideBand
WLAM	Wideband Low Activity Mode

4 Comments on the System Reference Document

Comments during AbC were received and considered in the present document.

5 Background information

5.1 The current situation, 24 GHz NB versus 24 GHz WLAM

The recent and successful deployment of the 24 GHz NB (Narrow-Band) radar technology has some limitations in object resolution but it was shown that this technology:

- Can address many of the short and mid range driving assistance and road safety features with a 200 MHz bandwidth: the first launch was related to rear applications (Blind Spot Detection & Lane Change Assist in 2006/7), followed by front applications (Front Collision Warning in 2009).

- Can be implemented, as noted in the ITU Draft report SM.2153 [i.20], Appendix 1, in the category "detection of movement and alert".
- Can be implemented on all class of cars.
- Will generate significant sales (> 1 Mu/y expected next year) which will support enhanced cost reductions thus speed-up the safety feature deployment. New low-cost sensors are expected in the 2012-2013 time-frame.

The 24 GHz NB radar technology is mainly used for rear applications. The introduction of this technology for front applications will be limited to short/mid range applications.

The 24 GHz NB radar technology is covered by a new harmonized standard EN 302 858 [i.18] and cannot cover parking aids because of the limited bandwidth. Parking is not a priority function for such radars since the ultrasonic technology is standard for lower end cars.

The WLAM concept is a way to improve the existing 24 GHz NB technology, to improve the detection of objects in critical driving situations, i.e. pedestrian detection in parking lots.

Present NB-24 GHz REAR type applications are used in:

- Blind Spot Detection (10 m warning) in production.
- Cross Traffic Alert (25 m warning) in production.
- Lane Change Assist (70 m warning) in production.
- Rear Pre-Crash (60 m range) in production.

Present NB-24 GHz FRONT applications are predicted for the 2010-2013 time-frame to the market:

- Forward collision warning.
- Front pre-crash and automatic braking.
- Low-cost ACC, zero speed up to 130 km/h.

There are classes of real world scenarios that cannot be addressed by 24 GHz NB radar systems. A real world scenario is typically a pedestrian emerging from between two parked vehicles. Spacing between parked vehicles is often on the order of (or less than) the 24 GHz NB resolution capability, thus the NB radar would be unable to identify sufficiently a pedestrian location as compared to wideband radar systems.

The 79 GHz long range radar (ACC) does not cover short range radar and is designed for longer range cruise control maintaining a minimum distance to the foregoing vehicles.

The 24 GHz NB radar technology has a significantly lower cost than the 77 GHz technology, which means that the 24 GHz NB radar technology has a high growth rate and is being implemented on middle-class and family cars.

5.2 The 24 GHz UWB Radars

In 2004 and 2005, two frequency bands were identified for the introduction of automotive UWB SRR (Short Range Radar) technology in Europe [i.1], [i.2], [i.3], [i.6]:

- the 24 GHz frequency range (i.e. 21,65 GHz to 26.65 GHz), as a temporary band for UWB SRR systems (24 GHz UWB SRR);
- the 79 GHz frequency range (i.e. 77 GHz to 81 GHz), as a permanent band for UWB SRR systems (79 GHz UWB SRR).

The European frequency regulation currently requires UWB SRR to migrate from 24 GHz to 79 GHz spectrum in the year 2013. Decision 2005/50/EC [i.1] on the 24 GHz frequency range stipulates that a fundamental review of the Decision should be carried out by 31 December 2009.

In the course of the fundamental review the EC issued a mandate in 2 parts on SRRs and requested a CEPT Report and a report for SRRs and alternative technologies.

Recently the ECC approved CEPT Report 36 [i.5] "Report from CEPT to the European Commission in response to Part 1 of the Mandate on Automotive Short-Range Radar systems (SRR)" for submission to EC.

The ECC approved CEPT Report 37 "Report from CEPT to the European Commission in response to Part 2 of the Mandate on Automotive Short-Range Radar systems (SRR)" for submission to EC.

The reports concludes in particular the following:

- The semiconductor technology for 79 GHz is now available, system integration and validation of 79 GHz UWB products will not meet the target transition date of 2013. "... *The European frequency regulation for 24 GHz automotive radar is based on a frequency shift to 79 GHz technology in 2013. Today 79 GHz technology is not yet mature to make this step in time*".
- The existing regulation for UWB SRR in the 24 GHz frequency range should not be modified. "*As a conclusion for the 23,6 GHz to 24 GHz band and the EESS case, it appears clearly that there is no room for substantial change of status of SRR 24 GHz and related provisions*".

The assessment of the automotive short range radar scenario falls within Part 2 of the new EC Mandate on SRR and aims to consider the possibility to allow alternative bands for SRR systems. It has been developed by WGFM Project Team FM47 on UWB in parallel with ongoing compatibility studies performed within WGSE Project Team SE24.

The inclusion of WLAM compatibility study in the SRR-Mandate 2 was supported by WG-FM:

- "WG-FM also encourages the compatibility analysis to be developed on a technology neutral basis so as to address various technological approaches foreseen within the automotive industry in this frequency range for implementing road-safety applications" - liaison statement WG-FM to WG-SE, dated February 13, 2009.
- As a consequence the compatibility study is being performed by SE24, and it was decided to start an SRDoc in parallel.

5.3 The socio-economic benefits

The European Union's eSafety Initiative in 2003 established the goal to reduce the number of road fatalities by 50 % up to the year 2010. There are over 40 000 fatalities on the roads every year in the EU member states, resulting from 1,4 million accidents, with an equivalent cost of around € 200 billion/year, or 2 % of EU GDP.

WLAM radars contribute to the socio-economic benefit primarily by the reduction of pedestrian injury severity as shown in annex A, clause A.2 in more details.

6 Market information

6.1 General

The WLAM concept improves the existing Narrow Band technology and is capable of detecting short range and mid-range objects with limited object resolution in front of vehicles.

The 24 GHz NB radar technology has achieved a reliable performance in complex environments for BSD, LCA, FCW (available in city) and CTA (parking environment).

According to market figures, 24 GHz NB radars are now increasingly used in the automotive market since they can realize most of the *driving assistance* features (range up to 150 m). This should be considered in combination with ACC for highway driving as the medium range offered by 24 GHz NB radar would not be suited for highway scenarios.

6.2 Availability of 24 GHz NB radar and WLAM applications

24 GHz NB radars are already in production for front and rear applications; they can address also the mid-range applications since the 24 GHz technology has a higher cost reduction potential.

The limitations specific to NB radars with a 200 MHz bandwidth can be noticed in critical environments - such as parking. Limitations on pedestrian detection can be solved by an increase of the bandwidth operating at a low activity factor, which reduces the interference risk with existing services.

The 30 cm object resolution of the 450 MHz WLAM mode will be similar to the resolution of a 77 GHz ACC and pre-crash systems (e.g. bandwidth < 500 MHz used in Japan). The combination of WLAM sensors with ultrasonic sensors will allow an enhanced resolution in the very short range, and can be used for pedestrian detection in city and parking conditions however the resolution in critical situations is below the capability of UWB SRRs.

24 GHz NB Radars found a successful market using the current GaAs technology market growth will increase once the cheaper SiGe technology is introduced around the 2013 time frame.

The success of 24 GHz NB radars can be first explained by its availability, which allows gradual implementation of some driving assistance and road safety applications in cars. Some industry suppliers have announced that ACC Stop and Go with pre-crash applications is foreseen for production in 2013. These radar based systems would fit the proposed EU regulation to mandate automatic emergency braking systems for medium and heavy commercial vehicles from 2013 onwards [i.13].

6.3 Production volumes

The production of 24 GHz NB radars are projected for over 1Mu/y by end 2010, mainly for rear applications

By the end of 2013, the production is anticipated to exceed 3 Mu/y.

After 2013, the deployment of front applications and low-cost radars will enhance the growth.

6.4 Outlook

The implementation of the WLAM mode with an extended frequency range of 24,05 GHz to 24,50 GHz will remedy some limitations encountered by the 24 GHz NB radars in certain driving conditions, with a primary focus on pedestrian detection.

The key-benefits are:

- the improvement of an existing radar 24 GHz NB radar standard technology which has a worldwide frequency allocation;
- to complement the existing detection devices supporting pedestrian detection (ultrasonic sensors), by using the radars already available on the car to improve field of view and detection range;
- benefit from the relatively high power of the 24 GHz NB radars over a larger bandwidth, to better discriminate pedestrian in parking or city environments;
- get an easy and immediate safety benefit due to the large deployment of the 24 GHz NB technology for the rear radar applications;
- generate new opportunities based on cheap 24 GHz NB mid range ACC radars, which could also support pedestrian detection when a front camera will be available.

Critical factors

Some industry stakeholders believe that there are indeed some limitations compared to 77 GHz to 79 GHz systems, mainly on the range resolution and the detection range. Proposed enhancement of this technology (by WLAM) is to address some critical "pedestrian protection" scenarios but would still leave some long range features and some specific safety scenarios uncovered. For example current 24 GHz NB radars are likely to be less effective in dealing with accident situations involving a single vehicle and a stationary object.

The 24 GHz NB radar improvement by the extension range beyond the ISM band limits creates a new situation and challenge for global harmonization and compatibility studies in many countries are needed for effective worldwide deployment of the extension range.

WLAM performance is in between the lower performing 24 GHz NB radar and the higher performing UWB SRR with regard to the object resolution.

7 Technical information

7.1 Detailed technical description

24 GHz NB radars with a 200 MHz bandwidth have limitations which can be noticed in critical environments - such as parking, limitations on pedestrian detection. These can be solved by WLAM which increases the bandwidth but operates at a low activity factor, which reduces the interference risk with existing services.

The 30 cm object resolution of the 450 MHz WLAM mode will be similar to the resolution of a 77 GHz ACC and pre-crash systems (e.g. bandwidth < 500 MHz used in Japan). The combination of WLAM sensors with ultrasonic sensors will allow an enhanced resolution in the very short range, and can be used for pedestrian detection in city and parking conditions however the resolution in critical situations is below the capability of UWB SRRs.

The narrowband radar can switch from the "ISM-only mode" to the WLAM mode when certain traffic or driving situations are sensed or identified.

The automatic switching between the "ISM mode" and the WLAM is initiated by the vehicle's electronic control unit by processing information from additional sensors such as a front camera for detection of pedestrians in the vehicle path, the usage of the reverse gear (parking situation) or active braking in order to complement passive protection of the driver and passengers. In the forward mode, the WLAM can be activated for vehicle speeds above 20 km/h (when triggered).

Consequently, the usage activity factor of the WLAM is limited, and is typically in the range of less than 0,5 % of the time when the vehicle is in use.

WLAM systems will have the flexibility to operate with an increased bandwidth of 450 MHz (200 MHz in the standard mode) and a low activity factor. The WLAM mode is activated for specific driving situations, to improve the detections of critical environments when the separation of targets is difficult (i.e. pedestrian detection support in parking lots).

7.2 Status of technical parameters

7.2.1 Current ITU and European Common Allocations

Table 1 gives allocations in the range of 24,25 GHz to 24,50 GHz.

Table 1: Existing allocations in the 24,05 GHz to 24,50 GHz band

Frequency Band	Allocations	Applications
24,05 GHz to 24,25 GHz	RADIOLOCATION Amateur Earth Exploration-Satellite (active) Fixed Mobile	Amateur (24,0 GHz to 24,25 GHz) ISM (24,0 GHz to 24,25 GHz) Non-specific SRDs (24,0 GHz to 24,25 GHz) SAP/SAB and ENG/OB (24,0 GHz to 24,5 GHz) Defence systems Detection of movement Weather satellites Detection of movement (24,05 GHz to 27,0 GHz)
24,25 GHz to 24,45 GHz	FIXED MOBILE	SAP/SAB and ENG/OB (24,0 GHz to 24,5 GHz) Detection of movement (24,05 GHz to 27,0 GHz) SAP/SAB P to P audio links (24,25 GHz to 24,5 GHz) SAP/SAB P to P video links (24,25 GHz to 24,5 GHz)
24,45 GHz to 24,5 GHz	FIXED MOBILE	SAP/SAB and ENG/OB (24,0 GHz to 24,5 GHz) Detection of movement (24,05 GHz to 27,0 GHz) SAP/SAB P to P audio links (24,25 GHz to 24,5 GHz) SAP/SAB P to P video links (24,25 GHz to 24,5 GHz)
Legend: The standard mode: in green. WLAM bandwidth extension: in yellow.		

The 24 GHz-ISM band has been implemented for the "Movement Detection & Alert" category in all the main countries, since supported by a ITU recommendation for SRDs (Short Range Devices).

The standards applying are usually based on either the FCC standard or the EU standard.

Step by step, 200 MHz with 20 dBm max. e.i.r.p. has been allocated in all the countries. In May, the 200 MHz has been completed and approved in Japan.

Table 2: Overview of NB Radar standards applied in different regions

Countries	Standard Identical/Similar to
USA/CANADA	FCC (Part 15.249 [i.25])
MEXICO	FCC (Part 15.249 [i.25])
BRAZIL	FCC (Part 15.249 [i.25])
CHINA/TAIWAN	FCC (Part 15.249 [i.25])
EUROPEAN COMMUNITY	EN 302 288-2 [i.19] (V1.3.2) new harmonized standard recently approved
Rest of EUROPE	EN 302 288-2 [i.19] (V1.3.2)
RUSSIA	EN 302 288-2 [i.19] (V1.3.2)
KOREA	EN 302 288-2 [i.19] (V1.3.2)
JAPAN	ARIB

The currently available regulations in other administrations for WLAM are the following:

- USA: Parts 15.245 (see note 3) and 15.249 (see note 4), in general Part 15 [i.25].
- Canada: RSS-210 [i.26].

Table 2 provides an overview over the NB Radar standards in different regions.

The regulatory environment of 24 GHz NB radar is primarily given by Footnote 5.150 of the Radio Regulations (ISM applications) and therefore has the potential for worldwide implementation. 24 GHz NB-radar technology with a 200 MHz bandwidth and a 20 dBm peak which has been approved in USA, Canada, Brazil, EU, China/Taiwan, Korea, Russia and Ukraine. The 200 MHz band is under study in Japan where only a 76 MHz bandwidth is currently permitted.

The regulatory situation for the extended range WLAM in the ITU and for global harmonization is critical since the range from 24,25 GHz to 24,50 GHz is outside the ISM band and critical for compatibility to other services considering the level of +20 dBm.

7.2.2 Sharing and compatibility studies (if any) already available

There are no studies available.

7.2.3 Sharing and compatibility issues still to be considered

To facilitate the compatibility an activity factor of 0,5 % is proposed. Individual compatibility studies in the various countries for harmonization are needed.

The following sub-clauses present the scenarios and status of the compatibility studies with WLAM.

7.2.3.1 Scenario with WLAM in calibration mode

This scenario is similar to the one used for SRR in ECC Report 23: a fixed link is parallel to a road on a 3 km length (see figure 1).

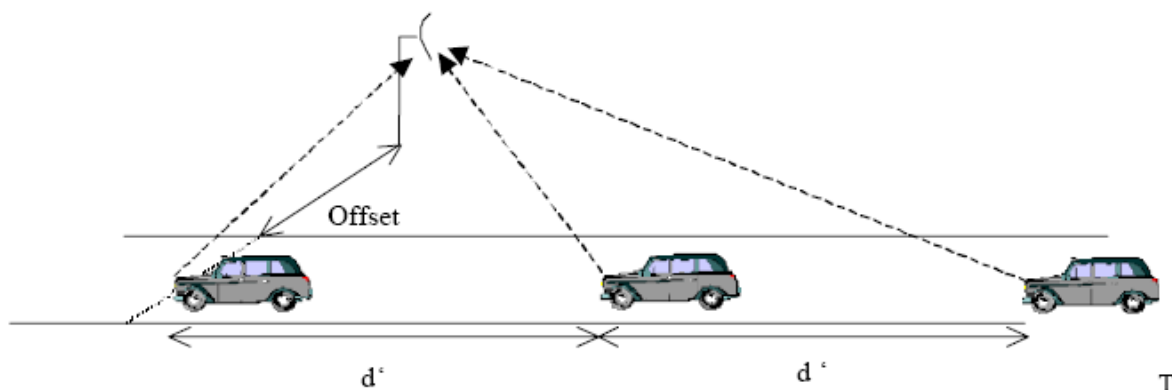


Figure 1: Scenario (extract from ECC Report 23 [i.11], figure 17)

The characteristics of the fixed point-to-point link and the scenario configuration are those described in ECC Report 23 [i.11]:

- Noise floor : -168 dBm/Hz.
- FS reception bandwidth : 50 MHz.
- FS antenna height : 10 m.
- FS antenna offset to road : 10 m.
- Car spacing : 20 m.
- Rain attenuation : 0,6 dB/km.
- Car shielding : see formula in ECC Report 23, § 4.1.1.4.6 (p. 27) [i.11].
- Bumper attenuation : 3 dB.

For the calibration mode, the worst case scenario with the fixed services from ECC Report 23 [i.11] is used as a reference.

7.2.3.2 Scenario with WLAM in rear parking mode

For the rear parking mode, concrete characteristics and use-cases of SAP/SAB systems at 24 GHz are still missing to build a real world scenario, since it seems as if no deployment has started.

Administrations are invited to provide characteristics of ENG/OB in the band 24,25 GHz to 24,50 GHz (see ECC Report 002 [i.12]), noting that:

- the deployment of temporary fixed or mobile applications (ENG/OB) in this band could not be confirmed by the representatives of the countries attending the ECC-SE24 meetings;
- as an example, a recent public consultation released in July 2009 in the UK, dedicated to PMSE systems, did not receive any response in the 24,25 GHz to 24,50 GHz bandwidth. This was also the case in a recent EBU study (end of 2008) being discussed in the CEPT/ECC-PT FM45 [i.27].

7.3 Parameters

There are two 24 GHz NB technologies already on the market since 2006 and 2007:

- 24 GHz NB radars with fixed beams.
- 24 GHz NB multi-beam radars with scanning beams.

Table 3 shows a summary of the WLAM and 24 GHz NB radar technology. See more details in annex B.

Table 3: Summary of WLAM technologies

Specifications	24 GHz NB Fixed-Beam(s) Tx	24 GHz NB Multi-Beam Tx	Comments
A- STANDARD ISM MODE			
Bandwidth in standard Mode GHz	24,05 GHz to 24,25 GHz	24,05 GHz to 24,25 GHz	Existing frequency designation
Max e.i.r.p. Standard Mode	20 dBm	20 dBm	
Regulation applying	ERC REC 70-03 [i.8], Annex 5 EN 300 440 [i.17] / EN 302 858 [i.18]	ERC REC 70-03 [i.8], Annex 5 EN 300 440 [i.17] / EN 302 858 [i.18]	
B- WLAM/Low Activity Mode			
Bandwidth in GHz	24,05 GHz to 24,50 GHz	24,05 GHz to 24,50 GHz	Extended Bandwidth
Max e.i.r.p	20 dBm	20 dBm	consistent with existing 24 GHz NB
Activity factor at 20dBm e.i.r.p	< 0,5 % (to be consistent with clauses 7.1 and 7.2.3)	< 0,5 %	Estimate - see conditions of operation
Modulation	LFMSK or FMCW	LFMSK or FMCW	consistent with existing 24 GHz NB
Police Radar Mitigation Factor applying within the 24,075 GHz to 24,15 GHz band (Dwell Time restrictions)	$\leq 4 \mu\text{s}/40 \text{ kHz}$ dwell time every 3 ms Or $\leq 1 \text{ ms}/40 \text{ kHz}$ Dwell Time every 40 ms	$\leq 4 \mu\text{s}/40 \text{ kHz}$ dwell time every 3 ms Or $\leq 1 \text{ ms}/40 \text{ kHz}$ Dwell time every 40 ms	consistent with the new harmonized standard for existing 24 GHz NB / EN 302 858 [i.18]
EESS protection level	To be consistent with SRRs 26 GHz	To be consistent with SRRs 26 GHz	(1) -71,0 dBm/MHz in main beam $\pm 20 \text{ dB}$ average side lobes for Elev. > 30°
Antenna 10 dB beam-width in Azimuth	< 40° max	< 35° max per beam	
Antenna Pattern in elevation Angle above horizontal	At +20° elev: -10 dB At +25° elev: -20 dB > +25° elev: -23 dB average	At +20° elev: -10 dB At +25° elev: -20 dB > +25° elev: -23 dB average	-
Antenna gain	> 6 dBi	about 6 dBi	F (beam) for multi- beam
Duty Cycle in 24,25 GHz to 24,50 GHz band	See conditions of operation	See conditions of operation	-
Number of radars per cars (typical)	2 rears 1 front	2 rears 1 front	some premium cars might have 2 front radars
Number of radars simultaneously activated in a 50 MHz band/WLAM mode	1	1	Non synchronized emissions
Mounting position / 2 rear radars	rear bumper, delta pointing angle > 40° + height of about 50 cm	rear bumper, delta pointing angle > 40° + height of about 50 cm	-
Percentage of cars equipped	up to 50 % penetration rate	up to 50 % penetration rate	

7.4 Information on relevant standard(s)

The 24 GHz NB radar technology is covered by a new harmonized standard EN 302 858 [i.18] and is not covering parking aids because of the limited bandwidth.

8 Radio spectrum request and justification

The regulatory environment of 24 GHz NB radar is primarily given by footnote 5.150 of the Radio Regulations (ISM applications) and therefore has the potential for worldwide implementation. 24 GHz NB-radar technology with a 200 MHz bandwidth and a 20 dBm peak which has been approved in USA, Canada, Brazil, EU, China/Taiwan, Korea, Russia and Ukraine. The 200 MHz band is under study in Japan where only a 76 MHz bandwidth is currently permitted.

The regulatory situation for the extended range WLAM in the ITU and for global harmonization is critical since the range from 24,25 GHz to 24,50 GHz is outside the ISM band and critical for compatibility to other services considering the level of +20 dBm. To facilitate the compatibility a low activity factor is proposed. Individual compatibility studies in the various countries for harmonization are needed.

See more details in clause A.2.3.

9 Regulations

9.1 Current regulations

The "ISM mode" operating in the frequency range from 24,05 GHz to 24,25 GHz is covered by the following existing regulations, i.e. Europe: ERC Recommendation 70-03 [i.8], annex 5. The frequency band may also be covered by the amendment of EC Decision on SRDs 2006/771/EC [i.10] in the forthcoming revision.

Other international frequency regulations are given in clause 7.2.1.1.

9.2 Proposed Regulation and Justification

The proposed regulation is related to a supplementary mode and extension band to be used by the present 24 GHz-NB radars operating in the 24,05 GHz to 24,25 GHz. The extension band ranges from 24,25 GHz to 24,50 GHz and operates with a low-activity factor. In certain driving situations, this supplementary mode will be activated and it extends the usable radar bandwidth from 200 MHz (ISM Mode) to 450 MHz (WLAM Mode).

The bandwidth used will be therefore from 24,05 GHz to 24,50 GHz, the maximum e.i.r.p. will be 20 dBm as in the ISM mode.

The unwanted emissions in the frequency band 23,6 GHz to 24 GHz are proposed to be consistent with the conditions agreed for SRR-26 GHz UWB. For the unwanted emissions in the frequency band above 24,5 GHz, see clause B.2.1.

The benefits of improving the current 24 GHz-NB technology by a WLAM mode are the following

- Many car-makers are already in production with 24 GHz NB radar for rear applications. Any improvement (with extended range) will have an early benefit to the road safety, because it is an available radar technology.
- WLAM is a minor change in radar sensors, and will use the same signal processing and transmitting power as today: it can be implemented with low re-validation costs (no investment required in a new technology) and can be adopted by all the current customers depending on the national regulations.
- WLAM is a focused improvement of the 24 GHz NB technology which enjoys a global frequency designation, however global harmonization for the WLAM extension range between 24,25 GHz and 24,5 GHz with +20 dBm has to be pursued.
- WLAM is not expected to generate any significant compatibility issues, since the potential victims in the 24,25 GHz to 24,50 GHz band will not likely get any outdoor deployment (e.g. SAP-SAB links will not be used for outdoor applications at 24 GHz) and SAP-SAB equipments are unidirectional equipment.

24 GHz NB automotive radars equipped with a WLAM mode can offer a "practical approach" to improve the 24 GHz NB radars for collision mitigation applications in order to support the EU policy goals.

Annex A: Detailed market information

A.1 Applications

The usage scenarios include specific driving situations. It provides an improved performance compared with narrowband radars operating within the ISM frequency range from 24,05 GHz to 24,25 GHz by activating a larger bandwidth from 24,05 GHz to 24,50 GHz.

An overview and summary of the applications are provided under clause 5.3. The maturity matrix in table A.1 and figure A.1 show WLAM in the context with other competing technology solutions for technologies in line with the existing frequency allocation strategy.

Table A.1: Maturity matrix

Features	77 GHz	77 GHz + 79 GHz	24 GHz NB	24 GHz NB + WLAM
Adaptive Cruise Control 200 m long-range	PROD	A-SAMPLES 2012	not feasible	not feasible
Adaptive Cruise Control 100 m mid-range	See-long range	A-SAMPLES 2012	READY for serial dev	READY for serial dev
Front collision warning 100 m	PROD	A-SAMPLES 2012	PROD	PROD
Front Stop and Go and automatic braking 60 m	PROD (starting 2010)	A-SAMPLES 2012	READY for serial dev	READY for serial dev
Front pedestrian detection support	PROD (starting 2010)	A-SAMPLES 2012	not feasible	READY for serial dev
Rear blind spot detection 10 m	(see note)	(see note)	PROD	PROD
Rear lane change assist 70 m	(see note)	(see note)	PROD	PROD
Rear pre-crash 30 m to 60 m	(see note)	(see note)	PROD	PROD
Rear pedestrian detection support	(see note)	(see note)	not feasible	READY for serial dev
Rear parking aid 4 m to 6 m	not feasible	(see note)	not feasible	not feasible
NOTE: Not appropriate for integration and cost reasons.				

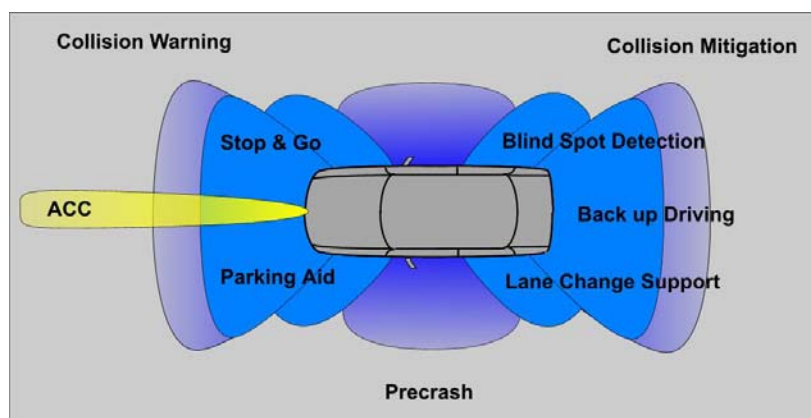


Figure A.1: Short/Mid/Long Range Radar Applications and Functions

Table A.2 provides an overview of Short Range Radar and safety applications.

Table A.2: Overview of Short Range Radar and safety applications (from CEPT Report 36 [i.5])

Applications		<p>This table contains the list of potential applications for short range radars. To be able to evaluate the benefits attached to each option of the Assessment, it is necessary to analyse whether the applications are supported in the case of each option.</p> <p>The table is based on the answers to the questionnaire on SRR issued by WGFM in May 2009, in particular answers to question b) "b) Which single technology (e.g. type of radar and frequency band) or combination of such technologies provides the safety/assistance feature?".</p> <p>(see note)</p>
Pedestrian protection (Active)	Active pedestrian protection (active braking/brake assist)	<p>Manufacturer 1: radar multi-beam working within 24 GHz NB or 77 GHz NB (79 GHz).</p> <p>Supplier 1: data fusion between vision and ultrasonic for short range, extended range possible with NB 24 GHz radar if WLAM gets approval.</p> <p>Manufacturer 2: 24 GHz narrow band for detection (+camera to classify pedestrians).</p>
Pedestrian protection (Passive)	Passive pedestrian protection (e.g. activation of airbags in the bumper, lifting the hood of the car, etc.)	<p>Supplier 1: data fusion between vision and ultrasonic for short range, extended range possible with NB 24 GHz radar if WLAM gets approval.</p>
Pre-crash (passive safety)	Passenger protection (air bag arming, etc.)	Not applicable.
Collision mitigation/avoidance (active safety)	Emergency braking	<p>Manufacturer 1: radar multi-beam working within 24 GHz NB or 77 GHz NB (79 GHz).</p> <p>Supplier 1: RFQ on-going for NB 24 GHz radar systems based on low-cost ACC.</p>
	Braking assistance	see emergency braking.
Collision warning	Emergency warning (front)	<p>Manufacturer 1: radar multi-beam working within 24 GHz NB or 77 GHz NB (79 GHz).</p> <p>Supplier 1: NB 24 GHz in production.</p>
	Emergency warning (rear closing vehicle)	<p>Manufacturer 1: radar multi-beam working within 24 GHz NB or 77 GHz NB (79 GHz).</p> <p>Supplier 1: SOP planned before 2013 for rear pre-crash with NB 24 GHz LCA radars.</p>
	Emergency warning (cross traffic)	<p>Manufacturer 1: radar multi-beam working within 24 GHz NB or 77 GHz NB (79 GHz).</p> <p>Supplier 1: NB 24 GHz in production.</p> <p>Manufacturer 3: 24 GHz to 29 GHz UWB SRR or 24 GHz Narrowband MRR.</p> <p>Manufacturer 2: 24 GHz Narrow band.</p>
	Lane change assist	<p>Manufacturer 4*: the system monitors the area on the neighbour lane and warns the driver if the lane is occupied (radar 24 GHz ISM).</p> <p>Manufacturer 1: radar multi-beam working within 24 GHz NB or 77 GHz NB (79 GHz).</p> <p>Supplier 1: NB 24 GHz in production.</p> <p>Manufacturer 3: 24 GHz to 29 GHz UWB SRR or 24 GHz Narrowband MRR.</p> <p>Manufacturer 2: 24 GHz narrow band.</p>
	Blind spot detection	<p>Manufacturer 4*: see lane change assist.</p> <p>Manufacturer 1: radar multi-beam working within 24 GHz NB or 77 GHz NB (79 GHz).</p> <p>Supplier 1: NB 24 GHz in production.</p> <p>Manufacturer 3*: 24 GHz to 29 GHz UWB SRR or 24 GHz Narrowband MRR*.</p> <p>Manufacturer 2*: 24 GHz narrow band.</p>

Driving assistance	Adaptive Cruise control	<p>Supplier 2: LRR (76 GHz to 77 GHz). Manufacturer 5*: used sensor LRR (76 GHz to 77 GHz). Supplier 4: currently offers the 3rd generation of adaptive cruise control, based on 76 GHz to 77 GHz technology. Manufacturer 4*: today 76 GHz to 77 GHz radar is used. Supplier 3: LRR. Manufacturer 1: radar multi rays working within 77 NB -81 GHz (79 GHz). Supplier 1: Several NB 24 GHz suppliers are proposing low cost ACC to start serial development now. General Motors*: 76 GHz to 77 GHz LRR. Manufacturer 2*: 77 GHz.</p>
	ACC Stop and Go	<p>Supplier 2: LRR (76 GHz to 77 GHz) combined with other satellite sensors. Manufacturer 5*: fusion of sensor data LRR (76 GHz to 77 GHz) and UWB SRR (24 GHz or 26 GHz) and camera (planned). Supplier 4: stop and go function needs UWB technologies for full functionality. Manufacturer 4*: today 76 GHz and 24 GHz UWB radar is used. Supplier 3: LRR in combination with UWB radar, early detection of a cut in (e.g. pedestrian or motorcyclist) requires UWB sensors. Manufacturer 1: radar multi rays working within 77 NB -81 GHz (79 GHz). Supplier 1: RFQ on-going for NB 24 GHz radar systems based on low-cost ACC, (Supplier 5 proposes a 24 GHz based radar device that enables stop and go ACC). Manufacturer 3: 76 GHz to 77 GHz LRR. Manufacturer 2: 77 GHz wide field of view or 77 GHz narrow field of view with 24 GHz.</p>
Parking assistance	Parking Assistance	<p>Supplier 2: ultrasonic sensors. Manufacturer 5*: currently ultrasonic sensors are used in a majority of cases (if radar is used 24 GHz UWB SRR). Supplier 4: parking applications (if based on radar) need UWB technology. Manufacturer 4: ultra sonic sensors. Supplier 3: UWB sensors. Manufacturer 1: no need of radar. Supplier 1: Parking assistance has become a quasi-standard feature with ultrasonic sensors (radar is too expensive to be a standard feature and does not bring any advantage). Manufacturer 3*: Ultrasonic and/or 24 GHz to 29 GHz SRR. Manufacturer 2*: ultrasonic sensors only.</p>

NOTE: Where a vehicle manufacturer is marked an asterisk (*), it indicates that the application is in production.

A.2 Market

The market overview and market penetration expectations are summarized in clause 5.3.

A.2.1 Socio-economic benefit and Safety contribution

Road safety policies can rely on various initiatives, including SRR, which is described in TR 102 664 [i.9] as an enabling technology for enhanced active safety systems e.g. the mitigation of rear-end crashes which will reduce damages and saving of lives.

According to some accident studies referred to in TR 102 664 [i.9], rear-end collisions dominate in collision statistics. For example in Germany, there are over 50 000 severe rear-end accidents every year, with 5 700 death cases or serious injuries. In the U.S., around 30 % of all traffic accidents are the result of rear-end collisions. Reducing these accidents by 20 % and additionally reducing the severity of an even higher percentage, would be a milestone in improving automotive safety.

Safety benefit expected with the 24 GHz NB standard mode

24 GHz NB is an enabling technology for enhanced active safety systems and in particular the mitigation of front-end crashes thus reducing damages and saving of lives. Accidents involving vehicles are related to traffic situations in which a faster reaction of the driver could have avoided crashes. Consequently, there is an increased need and appreciation for obstacle detection systems that operate at day and night.

The new generation of low-cost 24 GHz NB radars planned for 2013 will allow a quick deployment of the safety features on all cars.

Specific Safety benefit added with the WLAM Mode

WLAM will use the same 20 dBm max e.i.r.p. as for the standard ISM mode: this relatively high power allows pedestrian detection with a maximum range < 15 m.

This range is intermediate between the range of ultrasonic sensors (< 6 m) and the range of front cameras (25 m for pedestrians with low-cost technologies).

The strategy for WLAM Mode activation, is based on:

- a permanent activation when reversing out of a parking place to better discriminate pedestrians approaching behind the car in parking areas;
- an activation limited by a minimum speed for front driving, and conditioned to a crash assessment following a imminent pedestrian crash alert issued by a front camera;
- collision mitigation by braking to reduce the speed of a potential impact and complement the passive protection devices tested up to 40 km/h (EuroNCAP) (see figure A.2).

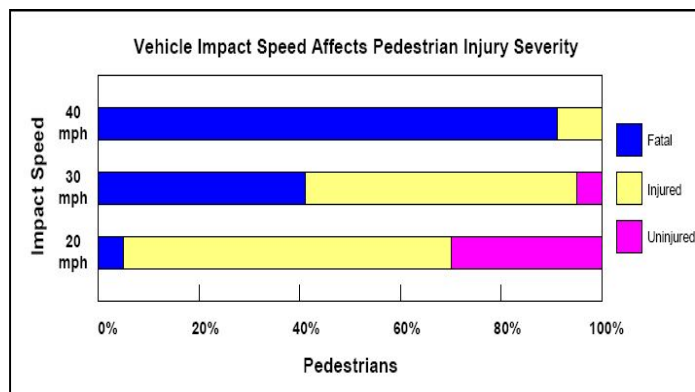


Figure A.2: Pedestrian injury severity as a function of vehicle speed

Furthermore, the analysis of accidents with pedestrians in France 2008 show that this type of accidents represents nearly 17 % of the injuries and that most of the fatalities happen:

- in urban areas (70 %);
- when the pedestrian is crossing the road (70 %);
- on the pedestrian cross-path or closer than 50 m from the cross-path (70 %).

Annex B: Technical information

B.1 Technical description

B.1.1 24 GHz NB systems overview

The 24 GHz NB radars typically use FMCW or LFMSK signals (sweeping frequency principles). 24 GHz NB uses multi-beam or high speed resolution techniques to monitor the road traffic to the front and to the rear.

Their main characteristics are summarized in figure B.1 and show:

- 24 GHz NB can cover short and mid- range applications, but not long range applications.
- 24 GHz NB is using multi-beam or high speed resolution techniques to perform a monitor the road traffic to the front and to the rear.
- A WLAM mode will improve the range resolution in certain critical driving situations, and be sufficient to improve the performance in some specific driving situations where a larger bandwidth is critical.

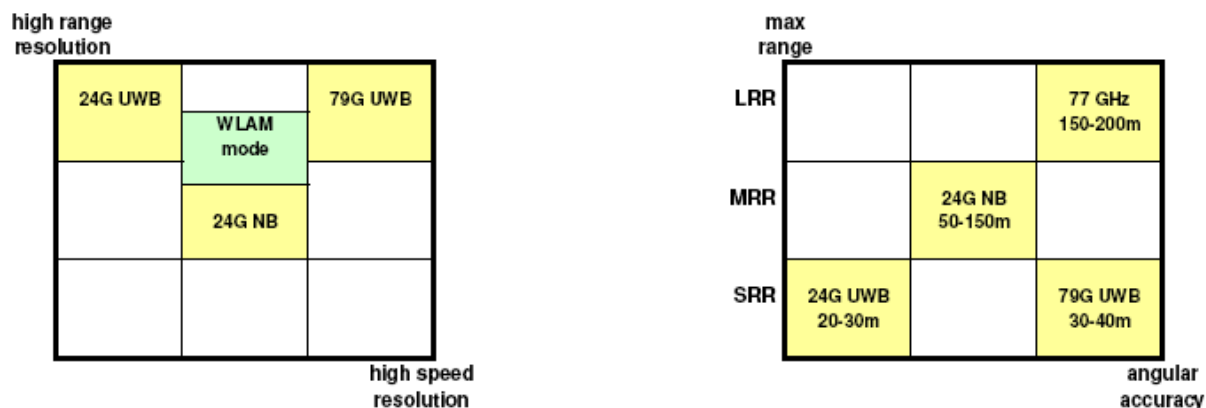


Figure B.1: Main characteristics of automotive radar technologies

B.1.2 Design considerations to go from 24 GHz NB to WLAM systems

The implementation of WLAM is a limited evolution of the 24 GHz NB products since the power, signals and signal processing will remain the same as for the 24 GHz NB ISM standard mode.

Table B.1 gives the braking distance related to a normal and emergency braking and shows the timing for WLAM activation which happens when the driver does not brake in time to avoid a crash.

The calculation of the timing for the braking actions takes into account the assumptions of table B.1.

Table B.1: Assumptions for braking actions

Braking force (g)	0,7
Delay to get requested brake demand (s)	0,3
Time to get active WLAM tracking (s)	0,3

Table B.2 gives the braking distance related to a normal and emergency braking and shows the timing for WLAM activation which happens when the driver does not brake in time to avoid a crash.

Table B.2 summarizes the timing scenario for braking actions for different speed assumptions.

Table B.2: Active braking and WLAM activation for Pedestrian Protection

WLAM activation time for Pedestrian Detection Support	Parameters	Speed in km/h				
		30	40	50	60	65
speed in m/s		8,3	11,1	13,9	16,7	17,9
Breaking Time in sec (to 0 kph) including WLAM activation	Deceleration(g)	1,8	2,2	2,6	3,0	3,2
Distance for emergency braking (in m)	0,7	10,1	15,7	22,4	30,2	34,2
Including 0,3s delay to get the required braking force						
Distance for normal braking (in m)	0,4	13,3	21,1	30,7	42,4	56,0
Distance including a 2m safety distance at stop						
Time to Collision at Camera Pre-crash Alert event (in sec)	Range in m	3,0	2,3	1,8	1,5	1,4
	25					
WLAM Activation Delay in sec		0,3	0,3	0,3	0,3	0,3
WLAM activation duration until Impact	seconds	-	-	-	1,5	1,3
WLAM activation duration until a stop	seconds	1,8	2,2	2,6	-	-
Final speed after emergency braking (in km/h)		0	0	0	30	40
		no collision	no collision	no collision	EuroNCAP	EuroNCAP

The active safety sequence with WLAM activation is (see details in clause B.2.3.3):

- Step1: The front camera will be first to detect a pedestrian in the path and will report an imminent crash alert with a pedestrian.
- Step2: A crash assessment is performed based on the information from the front camera and the behaviour of the driver: if the driver is not braking in time, an active braking with activation of WLAM might be required.
- Step3: The braking system is activated to reduce the speed of impact or stop the car before the impact, and the pedestrian detection is improved by the activation of WLAM.

To be consistent with the ultrasonic range coverage, a minimum activation speed of 20 km/h is proposed for WLAM.

B.1.3 WLAM activation

B.1.3.1 WLAM activation principle

The WLAM activation mode has been defined to improve 24 GHz NB radars.

Its purpose has been the detection of specific targets in some critical driving conditions with the focus on Active Braking for Pedestrian Protection Support (APPS).

B.1.3.2 WLAM activation conditions

Table B.3 provides the overall activation conditions of WLAM.

Table B.3: Summary of WLAM Activation Conditions

Scenarios	Rear Driving	Front Driving
Low-speed Activation	X Permanent with rear gear	NO
High-speed Activation	NO	X Above 20 km/h + crash assessment

The potential crash assessment criteria are the following (table B.4).

Table B.4: Crash assessment criteria

Crash Assessment Criteria	Pedestrian in Path with a risk of collision plus driver does not brake in time	Pedestrian detection initially triggered by a front camera
	Car trajectory loss of control	Activation triggered by the braking system (ESP)

B.2 Technical justifications for spectrum

B.2.1 Power issues

Inband emissions:

The maximum e.i.r.p. for WLAM will be the same as for the standard ISM Mode: +20 dBm max e.i.r.p.

WLAM needs a 20 dBm power to achieve a good detection capability of pedestrians and keep a consistent tracking performance before and after the activation of the WLAM Mode.

The ISM mode will be the standard mode of the WLAM system, with an activity factor of at least 99,5 %.

Unwanted emissions:

The unwanted emissions in the out-of-band domain in the frequency band 23,6 GHz to 24 GHz are proposed to be consistent with the specifications defined for the SRR 26 GHz-UWB to achieve co-existence with the passive services. Specifications for the SRR 26 GHz-UWB have been defined as follows:

- Direct emission limit in the main beam will not exceed -73 dBm/MHz e.i.r.p.
- Additional average antenna attenuation above 30° elevation to be separately measured will be at least 20 dB.

In addition, Decides-5 of Decision ECC/DEC/(04)10 [i.2] for 24 GHz SRR defines a level of -74 dBm/MHz for the protection of the RAS without the necessity for a deactivation mechanism. Therefore, in addition to the constraint given in (b), the limit for the direct emissions was set to -74 dBm/MHz for the band 23,6 GHz to -24 GHz to protect EESS passive and the RAS. In the case of WLAM, 1 radar will be visible instead of 2 for SRR, resulting in a level of -71 dBm/MHz.

The unwanted emissions in the out-of-band domain below 23,6 GHz and above 24,50 GHz will be identical as for the existing standard applying to the 24 GHz NB radars.

Other emissions below 23,6 GHz and above 25,4 GHz that are not associated with the wanted emissions (e.g. from digital circuitry, microprocessors) are pursuant to the limits in ERC Recommendation 74-01 [i.7].

The existing 24 GHz ISM automotive radars are compliant with the ERC Recommendation 70-03 [i.8] to SRD devices, in the category "movement detection and alert".

The out of band emissions are specified in term of peak values. In Europe, the ETSI standard EN 300 440 [i.17] applies for the devices operating in the 24,05 GHz to 24,25 GHz band. The specification gives -30 dBm as a maximum peak value.

Feasibility test performed by a certified test-lab (Cetecom) to check the emissions in the passive Band.

Example of emissions in the passive band for a 24 GHz ISM system already in production: WLAM systems will have the same spectrum characteristics when using the same modulations.

The following test results show that the emissions within the passive band from a 24 GHz NB-radar were under the noise floor of -66 dBm/MHz, see figure B.2.

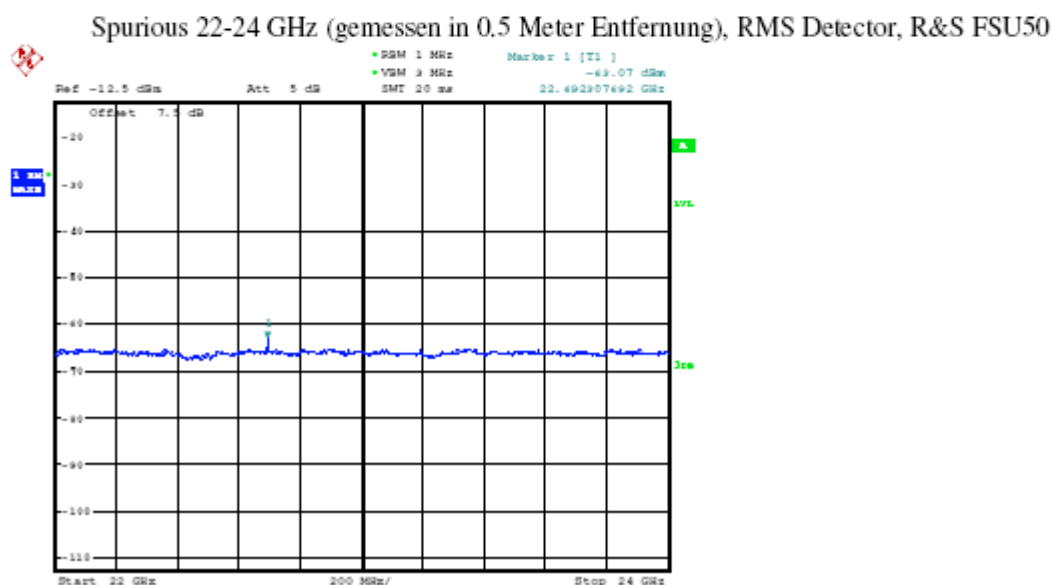
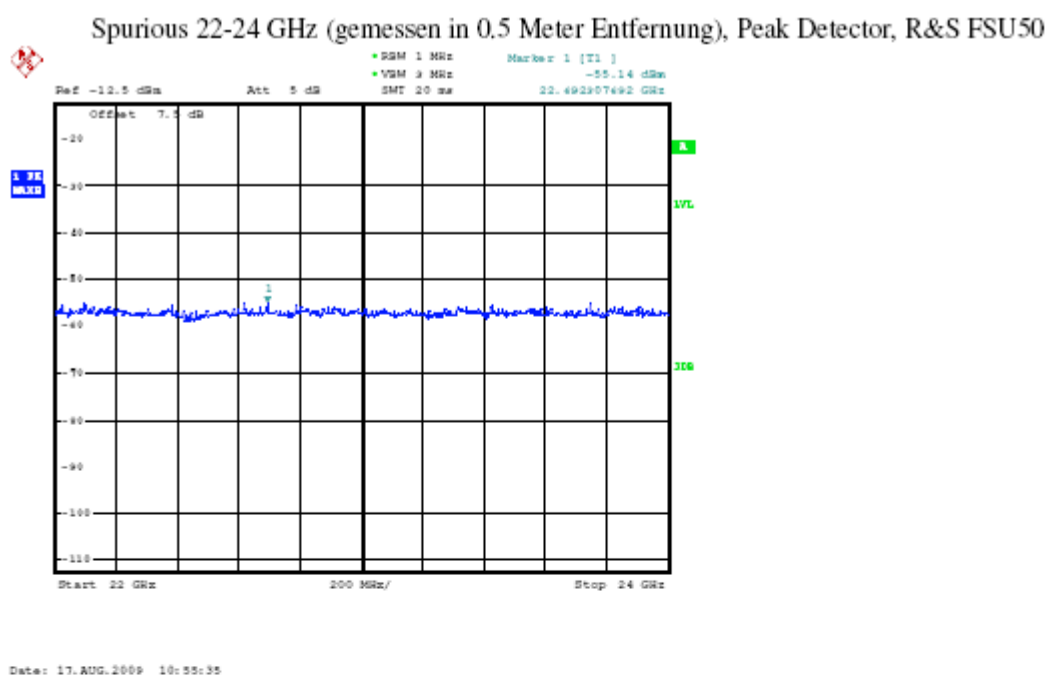


Figure B.2: Emissions in the passive band from a 24 GHz NB radar (Example)

B.2.2 Frequency issues

WLAM uses an extended bandwidth of 450 MHz (200 MHz in the standard ISM mode): 24,05 GHz to 24,50 GHz. This bandwidth is compliant with the generic deployment of the fixed services above 24,50 GHz.

Figure B.3 provides the Frequency Allocation overview for WLAM and the Fixed Services.

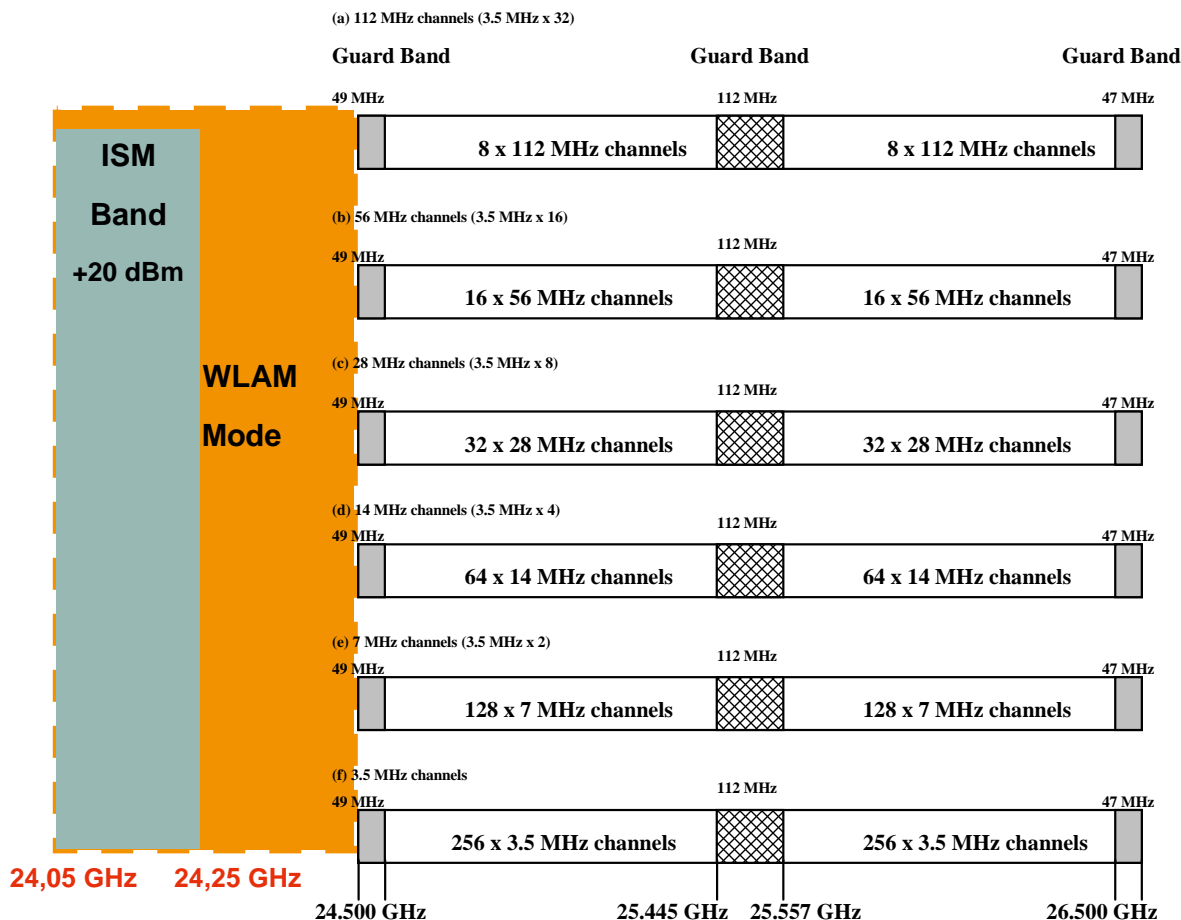


Figure B.3: Frequency allocation for WLAM and the Fixed Services

B.2.3 WLAM activity factor

The WLAM activity factor is limited to avoid the risk of interference.

There are 3 activation modes for WLAM:

- Front Driving Mode, related to an Active braking for Pedestrian Protection (APPS) which will have a very low activity factor, and will not be activated in parking conditions (activation will happen above a minimum speed).
- Rear Driving Mode, which is activated only with the rear gear and therefore will have a low activity factor.
- Calibration Mode, which is a low-power and low-duty cycle mode required to switch from the ISM mode to the WLAM mode.

B.2.3.1 Activation conditions of the WLAM mode

The use of a wider bandwidth is minimized by activating WLAM only in specific configurations, as described in table B.5.

Table B.5: ISM Standard mode and WLAM operational characteristics

Mode or Activation event	e.i.r.p.	Modulation bandwidth	DC or maximum duration	Technical conditions of activation	Probability of activation
Standard ISM mode	+20 dBm	200 MHz (24,05 GHz to 24,25 GHz)	--	--	100 %
Calibration	-11 dBm (24,25 GHz to 24,495 GHz) -8 dBm (24,495 GHz to 24,5 GHz)	450 MHz (24,05 GHz to 24,50 GHz)	0,25 %/s/25 MHz within 24,25 GHz to 24,495 GHz 1,5 %/s within 24,495 GHz to 24,5 GHz	Gear in forward drive mode Forward looking radar only	100 %
Active braking for Pedestrian Protection System (APPS)	+20 dBm	450 MHz (24,05 GHz to 24,50 GHz)	5,6 %/s/25 MHz within 24,25 GHz to 24,5 GHz (latest SE24, was 2 %/s)	- V > 20 km/h, and - Emergency braking flag monitored by a forward looking camera in case of a crash event	Very low 0,014 s/km/year (was 0,03 s/km/y)
Rear parking	+16 dBm		2,3 %/s/25 MHz within 24,25 GHz to 24,5 GHz (latest SE24, was 5,6 %/s/25 MHz) during a parking manoeuvre	- V < 30 km/h, and Gear in reversing mode Rear facing radar only	0,6 event/km ² for a urban density of 453 veh./km ²

B.2.3.2 Controllability of the WLAM mode

The activation of WLAM cannot be triggered by the automotive sensor alone.

The activation of WLAM is to be triggered either by:

- Rear driving: the position of the gear box indicated by the car system (rear parking mode)
- Front-driving: an authorization coming from a sensing data fusion ECU or from another vehicle system ECU which is doing the threat assessment.

In the front driving mode, a maximum activity factor for WLAM will be programmed in the sensor as an additional guarantee that the activity factor will be capped. An algorithm to ensure that the maximum activity factor is not exceeded in the real life has to be defined and will have to be consistent with the safety requirements.

B.2.3.3 Scenario 1: Active braking for Pedestrian Protection Support (APPS)

WLAM in this front driving pedestrian detection mode will be activated only when the following conditions are met:

- speed vehicle > 20 km/h.
- input signal (flag) from the vehicle crash assessment system accounting for a pedestrian collision risk which requires an active braking sequence.

The collision risk with a pedestrian is initiated by a front camera. The front camera has a longer range than the radar, so that WLAM can be activated before the radar can detect the pedestrian.

In normal situations, the driver will start braking before the WLAM activation, and the WLAM APPS mode will not be triggered. Figure B.4 explains a typical activation diagram.

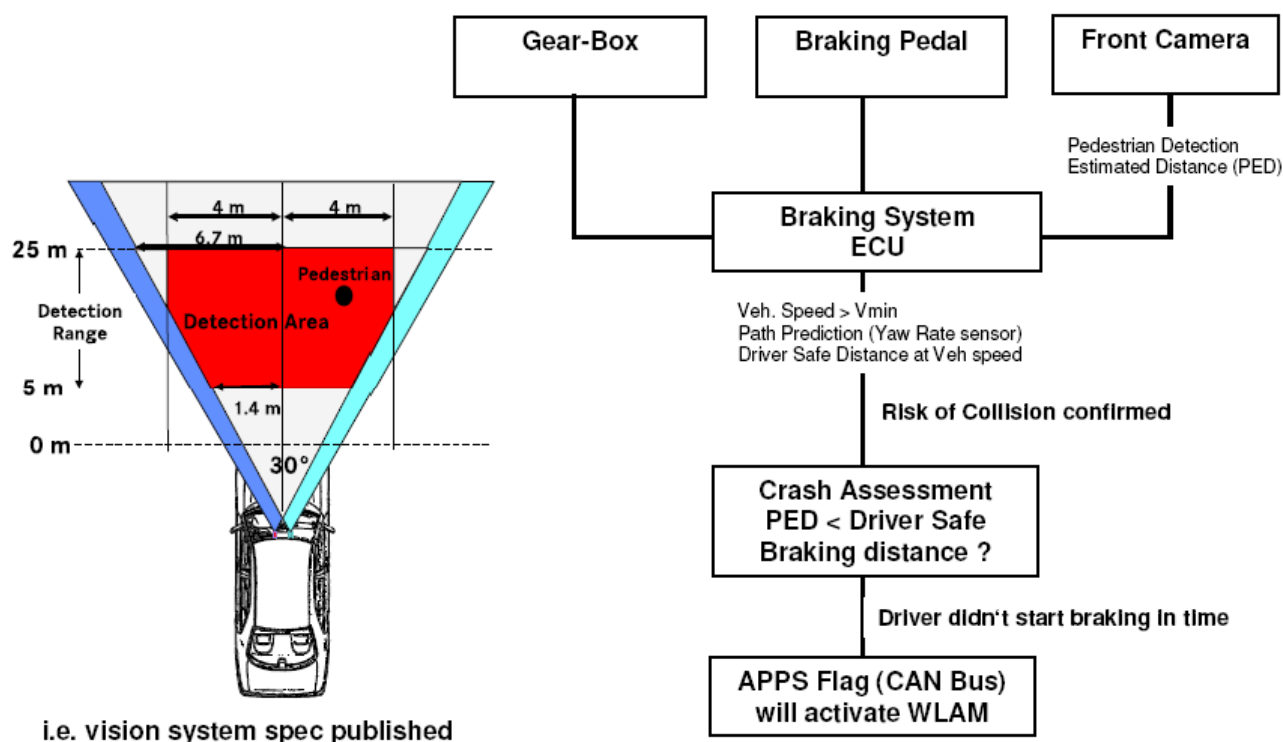


Figure B.4: Activation Diagram for APPS

The probability of WLAM-APPS activation can be derived from statistics from INSEE (French statistical institute) which reported 12 791 accidents with pedestrians in 2008 over the 1 014 378 km road network [i.14].

Table B.6 gives an overview of road accident injuries (France 2008) [i.15].

Table B.6: Overview of road accident injuries (France)

Accident conditions in France (2008)	Road accident injuries	
	Number	%
One vehicle only with pedestrian(s)	12 791	16,7
One vehicle only without pedestrian	15 888	20,7
Total accidents with one vehicle only	28 679	37,4
Two vehicles :		
- frontal collision	7 567	9,9
- lateral collision	23 199	30,2
- rear collision	8 358	10,9
- other collisions	4 067	5,3
Total accidents with two vehicles	43 191	56,3
Three vehicles and more :		
- chain collision	2 114	2,8
- multiple collisions	2 386	3,1
- other collisions	397	0,5
Total accidents with three vehicles and more	4 897	6,4
Total	76 767	100,0

Thus on a 1 km road segment, there is 0,013 accident per year on average, which is also the probability of activation for the WLAM APPS mode.

WLAM-APPS are operated 2,2 s on average this means that WLAM-APPS emissions occur less than 0,03 s per year on average on a 1 km road segment, representing 9e-8 % of time.

Therefore it is not expected that there is any significant interference issue with the front driving mode.

B.2.3.4 Scenario 2: rear parking mode

The rear parking mode aims at improving pedestrian detection improvement during parking manoeuvre.

Since the rear parking mode corresponds to the activation of the rear-gear position, WLAM-parking emissions are limited in time. An activity factor is estimated in table B.7.

Table B.7: Rear Parking Mode Activity Estimate

WLAM activation for rear-parking events	A (*) Activation per event (s) in average	C (**) Activation time per event in % of travel time	D Car Density (ECC Report 23 [i.11])	E Penetration rate %	F Number of systems activated
Urban	5,0	0,26% Veh $C = A/(32 \times 60 \text{ s})$	453 vehicles/km ²	50 %	0,59 systems/km ² $F = C \times D \times E$
Rural	5,0	0,26 %	123 veh/km ²	50 %	0,16

NOTE 1: (*) Average activation time per rear parking event - see clause B.2.3.8.1.
NOTE 2: (**) Average Travel duration of 32 min (rush hours and all drivers considered) - according to French statistics related to about 18 Millions of French workers, allocated to the different home and work situations in France, [reference: web site / as published in March 2007 by INSEE].

The low activity factor combined with the shadowing effect in parking conditions will reduce the interference risk.

B.2.3.5 Low-Power Calibration Mode

A permanent calibration mode is required for the WLAM forward looking radars to activate the WLAM mode.

The permanent calibration mode will use CW tones with the following characteristics

- -11 dBm max e.i.r.p. within 24,25 GHz to 24,495 GHz, and 0,25 % duty cycle in any 25 MHz band.
- -8 dBm max e.i.r.p. within 24,495 GHz to 24,5 GHz, and 1,5 % duty cycle in this 5 MHz band.
- Tone duration is fixed after radar initialization, the duration is in the range of 4 ms to 10 ms depending on the system.
- In the 24,25 GHz to 24,495 GHz band, the frequency of the CW tone f1, f2, f3 is changing between each activation, and spread over 100 MHz or more depending on the systems.

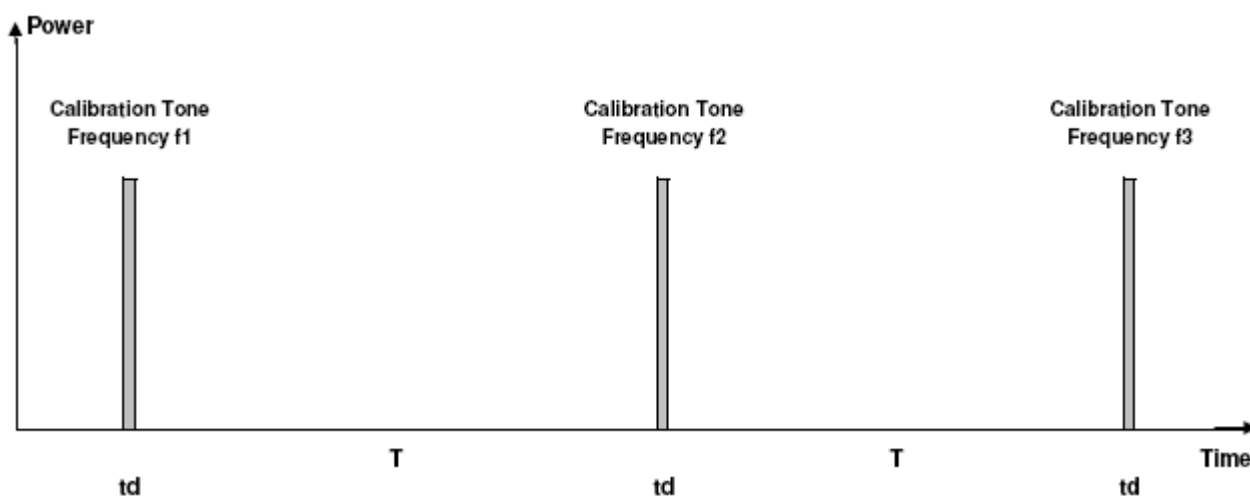


Figure B.5: WLAM Calibration Tones Timing Diagram

The low power and low duty cycle will reduce the risk of interference.

B.2.3.6 Summary of the activity factor for the WLAM mode

One needs to note the following aspects (summary):

- 1) The contribution of the rear driving mode is expected to be much greater than the contribution of the front driving mode.
- 2) For the rear driving mode, information about the statistics on the time percentage can be ultimately estimated since it is based on repetitive events and information is given in the present document.
- 3) For the front driving mode, WLAM activation is not triggered by the sensors themselves but is initiated by the vehicle's electronic control system, once an imminent crash alert with a pedestrian has been confirmed.
- 4) For the front driving mode, it is also proposed to limit WLAM activation based on the safety requirements, so that a maximum activity factor can be secured in this mode. This maximum activity factor can then be validated during the certification tests. An essential radio test suite will be included in the new Harmonized Standard for WLAM. The details of the implementation will be reviewed with ECC.

B.2.3.7 Statistics about travel duration

A report published in March 2007 by INSEE includes French statistics related to 18 million French workers, allocated to the different home and work situations in France [i.16].

The average travel duration is 32 min in rush hours (high density of cars).

The average travel distance is 26 km.

Table B.8 summarizes travel information as published by INSEE:

Table B.8: Travel information summary

	Distance (kilometers)		Duration in off hours (minutes)		Duration in rush hours (minutes)	
	average	median	average	median	average	median
Movement between several cities included						
Central cities	23,6	5,8	25	12	32	17
Suburbs	30,5	13,6	31	18	35	21
Country area	28,4	10,2	26	11	28	11
Group	25,9	7,9	26	13	32	18
Movement between several cities not included						
Central cities	34,3	9,7	36	18	46	27
Suburbs	35,1	15,6	35	21	40	20
Country area	40,2	17,4	37	19	39	20
Group	35,4	12,2	36	19	43	25
NOTE: Distance between home and work depending on the place of residence.						

For employees living in central cities, the average distance between work and their home is 23,6 km. For half of them, this distance is below 5,8 km.

For employees living in central cities and working in a city different from their city of residence, the average distance and the median one are respectively 34,4 km and 9,7 km.

B.2.3.8 Rear Parking scenario

B.2.3.8.1 Time per rear parking manoeuvre

The rear parking duration taken into account depends on the type of parking manoeuvres:

Parallel parking on road side:

- 12 s reversing time out of 15 s for a complete manoeuvre.
- 12 s to drive backwards + turn into the slot + reversing into the slot.
- 3 s to complete the manoeuvre by moving forward again.

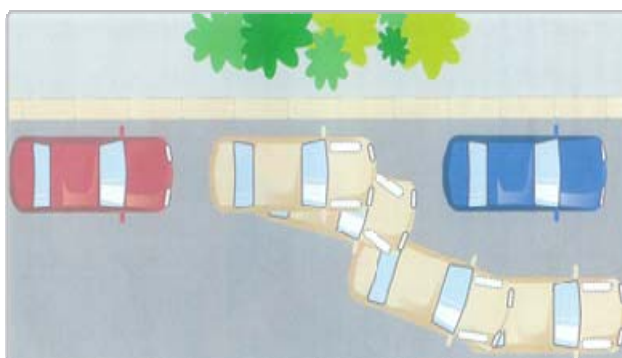


Figure B.6: Parking manoeuvre

Orthogonal Parking: 8 s reversing manoeuvre (simpler manoeuvre).

Front Parking: 0 s reversing manoeuvre (no reversing operation).

Overall timing considered in the compatibility study.

Table B.9: Study manoeuvre timing assumption

Rear Parking Duration	IN	OUT	%
road side parking	12	2	50 %
car park - backing manoeuvre	8	0	25 %
car park - forward manoeuvre	0	4	25 %
average	8,0	2,0	100 %
Average time per event (s)	5,0		

B.2.3.8.2 Dimensions of Parking Lots (reference for the shadowing effect)

Figure B.7 provides typical dimensions of parking lots in Europe.

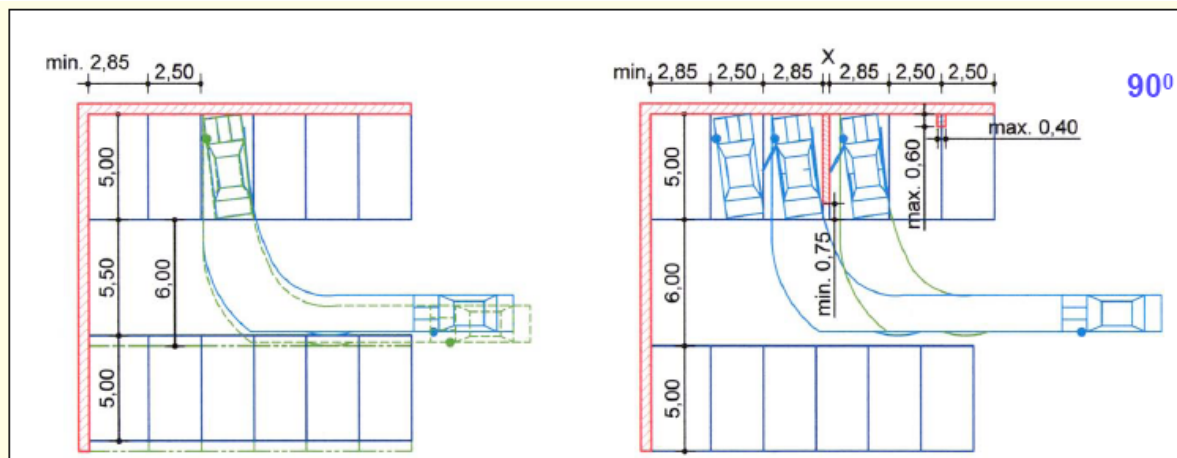


Figure B.7: dimension of parking lots in Europe

B.2.3.9 EBU view about the SAP/SAB deployment at 24 GHz



Working Group FM

66th Meeting of the WG FM

Montegrotto, 18 - 22 May 2009

FM(09)103

Date issued: 13 May 2009

Source: EBU

Subject: Potential frequency bands for ENG/OB under the WRC-11 AI 1.5

Summary

The EBU has considered the list of potential frequency bands for ENG developed by the CPG PTD under WRC-11 AI 1.5 (FM(09)076; Annex to Draft CEPT Brief on AI 1.5) and would like to make the following comments:

- The list of frequency bands is presented as a table in which the second column is named 'Preferred ENG usage'. As per ERC/REC 25-10 [i.22], the type of ENG application for each frequency band should be specified because there is a range of applications/links, with different technical parameters operating under the category of SAB/SAP or ENG. Certain types of applications/links are only applicable to certain frequency bands. For example in the 3400-3600 MHz band as preferred ENG usage it is indicated 'SAB/SAP'. As per ERC/REC 25-10 [i.22] it would be preferable to indicate 'Mobile video links (airborne and vehicular)'.
- The frequencies above 3 GHz are not feasible for uplink paths of mobile video links for technical reasons (high absorption of signals due to trees, difficult to use directional antennas) but they are feasible for the downlink path (airborne).

- For mobile video links (outside) it is not feasible to use the proposed frequency bands above 9,8 GHz for technical reasons (line-of-sight required). Such frequency bands could still be feasible for indoor usage (e.g. studio cameras).
- Concerning the 3400-3600 MHz band, there is the European Commission Decision of 21 May 2008 on the harmonisation of the 3400-3800 MHz frequency band for terrestrial systems capable of providing electronic communications services in the Community (2008/411/EC [i.23]).

Proposal

WGFM to consider the above mentioned EBU comments when dealing with the list of potential frequency bands for ENG/OB applications developed by CPG PTD under WRC-11 AI 1.5.

Background

CPG invited WGFM to comment on the list of potential frequency bands for ENG developed by the CPG PTD under WRC-11 AI 1.5. WGFM proposes to consider the list of frequency bands (see annex to Draft CEPT Brief on AI 1.5, FM(09)076) and develop liaison statement to CPG PTD on this issue.

B.3 Information on performance benchmarking with other short range radar solutions

Figure B.8 provides an overview of the key parameters as Doppler (object distance) resolution, the angle resolution and range or object discrimination resolution.

The comparison of figure B.8 shows that SRRs operating at the highest frequency and with high bandwidth provide the best SRR performance.

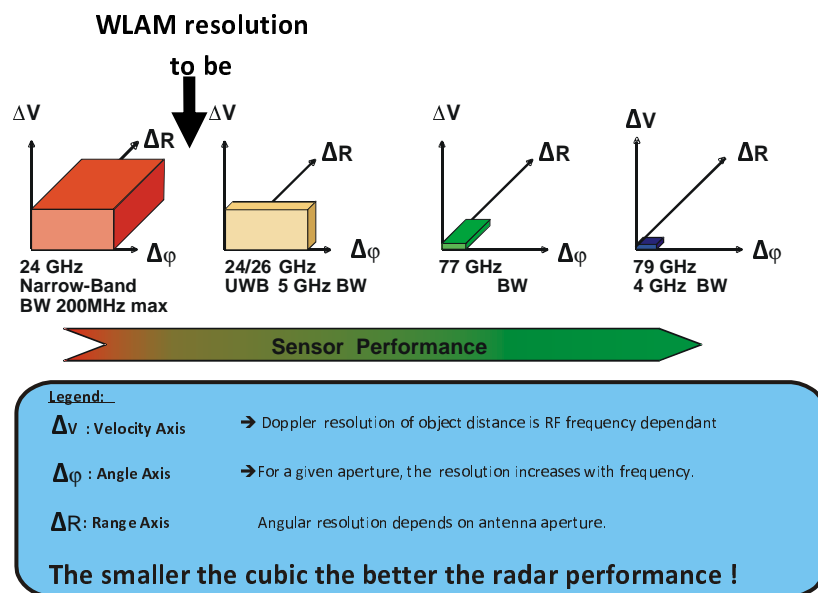


Figure B.8: Information about the resolution of automotive radar technologies

The 24 GHz narrowband radar uses the higher emission levels of the ISM band; the resolution of objects to be detected is limited by the available frequency bandwidth which is 200 MHz maximum.

The UWB SRR systems operating in the $24,15 \text{ GHz} \pm 2,5 \text{ GHz}$ or 24 GHz to 29 GHz range provide a higher spatial resolution given by the higher bandwidth. Also the range of the forward distance measurement to objects or cars is from near zero to about 30 meters. Several modules installed e.g. in front and backward bumpers provide a surround looking performance (see figure A.1).

The 77 GHz ACC radar is designed for long range forward looking distance measurement with narrow beam forming and combined with limited scanning performance. The systems are designed for automotive cruise control primarily on highways to maintain distance to proceeding vehicles within a pre-settable speed limit. The operating range is up to approximately 150 m, but the minimum operational distance is 30 m.

The 79 GHz systems provide enhanced performance for all three functions as measuring distance resolution, the detection and position determination of smaller object sizes and the relative velocity to other cars. The smaller size provides more designer freedom which is a continued requirement from the car industry.

The fact that the radar frequencies for ACC 77 GHz and 79 GHz SRR are adjacently allocated bands allows the combination of both sensor technologies in a single module. This lowers the system cost as compared to individual sensor modules provided for ACC and SRR individually.

The combined installation 24 GHz SRRs with 76 GHz ACC provides the optimum of safety functionality and is already practiced in cars on the road.

Manufacturer 7 has however announced a single 77 GHz radar with short range capability in production in 2010 on the new Manufacturer 7. The system manufactured by Supplier 6 enables ACC Stop and Go with pre-crash safety/emergency braking but also pedestrian protection and would be competitive for the mid-end vehicle segment.

Annex C:

Bibliography

- ERC Report 25: "The European table of frequency allocations and utilizations in the frequency range 9 kHz to 3000 GHz".
- ITU Radio Regulations.
- ECC-ETSI MoU (version of April 2004).
- RSPG Opinion on "Streamlining the regulatory environment for the use of spectrum", document RSPG 08-246.
- ECC/DEC/(02)05: "ECC Decision of 5 July 2002 on the designation and availability of frequency bands for railway purposes in the 876-880 MHz and 921-925 MHz bands".
- ETSI EG 201 788 (V2.1.1): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Guidance for drafting an ETSI System Reference document (SRdoc)".
- CEPT Report 37: "Report from CEPT to the European Commission in response to Part 2 of the Mandate on "Automotive Short-Range Radar systems (SRR)"".
- Evaluation of an automotive rear-end collision avoidance system (ACAS) by the NHTSA National Highway Traffic Safety Administration (document reference Ref DOT-VNTSC-NHTSA-06-01 /DOTHS 810 569).

NOTE: Available at

<http://www.nhtsa.gov/DOT/NHTSA/NRD/Multimedia/PDFs/Crash%20Avoidance/2006/HS910569.pdf>.

- Parking Structures: Planning, Design, Construction, Maintenance and Repair. Anthony P. Chrest, Mary S. Smith, Sam Bhuyan: 3rd Edition - February 2001 -Publisher: Kluwer Academic Publishers. Description of parking structure.

History

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