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)"

Final Report on 25 June 2010 by the

Electronic Communications Committee (ECC)
within the European Conference of Postal and Telecommunications Administrations (CEPT)

0 EXECUTIVE SUMMARY

This Report from the European Conference of Postal and Telecommunications Administrations (CEPT) to the European Commission (EC) has been developed in response to Part 2 of the Mandate to CEPT to undertake technical studies on automotive Short-Range Radar systems (SRR).

The EC Mandate on SRR was published on 7 November 2008. It calls for the delivery in March 2010 of a Final Report from CEPT to the Commission on Part 2 of the EC Mandate, subject to public consultation. CEPT Report 36 developed in response to Part 1 of the EC Mandate was finally adopted on 25th June 2010.

In detail CEPT has been mandated, under Part 2 of the EC Mandate, to undertake studies with regard to alternative approaches to the 24 GHz range for SRR use.

More specifically, CEPT has been mandated:

- where any alternative bands are to be considered for automotive short-range radar systems, to propose appropriate technical and regulatory measures to ensure the protection of existing radio services in or near any such bands;
- to consider in its work the results of the Commission's Call to stakeholders for Input on the fundamental review.

This CEPT Report was finally approved by the ECC at its meeting in June 2010.

The analysis carried out by CEPT under Part 2 of the EC Mandate on SRR consists of compatibility studies on ultra-wideband (UWB) automotive Short-Range Radars in the 24-29 GHz range and on 24 GHz narrow-band radars (24.05-24.25 GHz) with extension mode in the band 24.25-24.50 GHz (WLAM), as well as an assessment of the automotive short-range radars.

- *UWB SRR systems*

The technical elements for a possible new regulation designating the frequency band 24.25-27.50 GHz for automotive SRR systems are given in Table 2 of this Report (see section 3.4). However, CEPT could not reach a consensus on the regulatory measure.

A majority of administrations do not support the designation of a new frequency band at 26 GHz for UWB SRR systems (i.e. as per "Option B") that is likely to jeopardise efforts of vehicle manufacturers and suppliers which have focused on developing UWB SRR technology for operation in the 79 GHz frequency range

These administrations consider that allowing 26 GHz UWB SRR will result in market fragmentation for UWB SRR sensors. The consequence of that is reduction in the potential mass market, which will increase the cost of 79 GHz UWB SRR sensors with regard to the costs planned at present time and exclude volume of car makers (see Table 3 in Annex 2) from these safety applications. This situation will reduce the possibility of achieving the desired road safety benefits.

A few administrations support allowing Options B (26 GHz UWB SRR) & C (WLAM) in addition to keeping existing regulations for 24 GHz and 79 GHz UWB SRR systems as they are. The principle of technology neutrality supports the opening of the 26 GHz to UWB SRR. They have also indicated that, although the technical studies for 26 GHz UWB SRR are suggesting that the compatibility with radio services could be achieved without consideration of any time limit, a time limitation, if sufficiently ahead in time, can meet the present market requirements but would restrict the deployment of 26 GHz sensors.

This CEPT Report includes also a proposal from some administrations for extending the existing 24 GHz UWB SRR agreement but with some modifications to the terms of that agreement. This proposal raised objections which are explained in the report.

- *Narrow-band radars (24.05-24.25 GHz) with additional WLAM (24.25-24.50 GHz)*

CEPT considers it is still premature to envisage a regulatory measure for WLAM. The delivery of an ETSI SRDoc which was recently announced by ETSI would support preparing a more consensual regulatory proposal.

Therefore CEPT concluded to finalise this work outside the scope of the EC Mandate on SRR. Consideration of a new frequency band (24.25-24.50 GHz) for incorporation in Annex 5 of ERC/REC 70-03 would allow developing a stable regulation which could then be proposed, in a final step, for insertion in the Commission Decision on SRDs.

It should be noted that WLAM is not a substitute for UWB SRR but would compete with UWB SRR for some of the applications supported by UWB SRR.

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LIST OF ABBREVIATIONS

Abbreviation	Explanation
ARPOD	ARPOD project (*)
BER	Bit Error Rate (Bit Error Ratio)
CEPT	European Conference of Postal and Telecommunications Administrations
DC	Duty Cycle
EC	European Commission
ECC	Electronic Communications Committee (of CEPT)
ECO	European Communications Office
ES	Errored Seconds
ENG/OB	Electronic News Gathering/Outside Broadcast
ETSI	European Telecommunications Standards Institute
FH	Frequency Hopping
FS	Fixed Service
I/N	Interference to Noise ratio
KOKON	KOKON project (*)
LOS	Line of Site
NB	Narrowband
PPM	Pulse Position Modulation
RADAR ACC	RADAR ACC project (*)
RAS	Radio Astronomy Service
RoCC	RoCC project (*)
RMS	Root Mean Square (quadratic mean)
RTTT	Road Transport and Traffic Telematics
SAB/SAP	Services Ancillary to Broadcasting / Services Ancillary to Programming
SARA	Strategic Automotive Radar frequency Allocation[1]
SEB	Severely Errored Blocks,
SES	Severely Errored Seconds
SOP	Start of Production
SRDoc	System reference document
SRR	Short-Range Radar systems
SRS	Space Research Service
TR	Technical Report
UWB	Ultra-wideband
WLAM	Wideband Low Activity Mode

(*) See CEPT Report 36

[1] SARA was formed in 2001 as the **S**hort Range **A**utomotive **R**adar Frequency **A**llocation group; its mission to seek global harmonisation of regulations and standards to enhance road safety through UWB SRR. In 2007 it reformed as the **S**trategic **A**utomotive **R**adar frequency **A**llocation group, under the same acronym, to continue long term efforts towards effective frequency regulations worldwide for automotive radar in general.

**Report from CEPT to the European Commission
in response to Part 2 of the Mandate on
"Automotive Short-Range Radar systems (SRR)"**

1 INTRODUCTION

This Report from the European Conference of Postal and Telecommunications Administrations (CEPT) to the European Commission (EC) has been developed in response to Part 2 of the Mandate to CEPT to undertake Technical studies on automotive Short-Range Radar systems (SRR).

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In detail CEPT has been mandated, under Part 2 of the EC Mandate, to undertake studies with regard to alternative approaches to the 24 GHz range for SRR use.

More specifically, CEPT has been mandated:

- where any alternative bands are to be considered for automotive short-range radar systems, to propose appropriate technical and regulatory measures to ensure the protection of existing radio services in or near any such bands;
- to consider in its work the results of the Commission's Call to stakeholders for Input on the fundamental review.

This CEPT Report was finally approved by the ECC at its meeting in June 2010.

The analysis carried out by CEPT under Part 2 of the EC Mandate on SRR consists of compatibility studies on automotive UWB short range radars in the 24-29 GHz range and on 24 GHz narrow-band radars (24.05-24.25 GHz) with extension mode in the band 24.25-24.50 GHz (WLAM), as well as an assessment of the automotive short-range radar sector.

2 BACKGROUND

Two different frequency bands are currently available for ultra-wideband automotive short range radar equipment in Europe. The frequency band 21.65-26.65 GHz (the "24 GHz band") has been designated and made available for time-limited use by EC Decision 2005/50/EC of 17 January 2005 [1](within CEPT: amended ECC/DEC/(04)10 [2]). The frequency band 77-81 GHz (the "79 GHz band") has been designated and made available for permanent usage by EC Decision 2004/545/EC of 8 July 2004 [3] (within CEPT: ECC/DEC/(04)03 [4]). As already described in detail in CEPT Report 36 [5], the general strategy regarding the interim (24 GHz) and long term (79 GHz) solutions should not be changed from the CEPT point of view.

CEPT was mandated by the European Commission to study alternative solutions (see Part 2 of the "SRR Mandate 2" as provided in document RSCOM08-81 Final of 7 November 2008 (Annex 1)). The necessity for the Mandate was given by the fundamental review of the EC Decision on the 24 GHz band (required by Article 5 No. 2 of EC Decision 2005/50/EC) and also by the fact that the 24-29 GHz range (the "26 GHz band") had been proposed by automotive interests with a view to avoid compatibility problems with the passive radio services before moving to the 79 GHz band.

However, the proposed transition to the 26 GHz band requires that systems can co-exist without creating interference to existing services, including the fixed service. Frequency bands allocated to the fixed service are heavily used all over Europe within this frequency range.

Additionally ETSI submitted a final version of a system reference document on "Short range radar to be used in the 24 GHz to 29 GHz band" (ETSI TR 102 664 V1.1.1_0.11 (2009-03) [6]) to ECC in March 2009. In the meantime a draft revised version of this system reference document (Technical Report) has been provided by ETSI. This revised system reference document describes improved technologies for 26 GHz UWB SRR applications which result in lower interference potential due to improved mitigations for the services in the target frequency band. Furthermore the frequency band has been limited to 24.25-27.5 GHz (see draft ETSI TR 102 664 V1.2.1_1.1.3 (2010-02)). A further system reference document for narrow-band radar systems (24.05-24.25 GHz) with an additional Wideband Low Activity Mode (WLAM) within 24.25-24.5 GHz, which is only activated in specific driving conditions or in certain pre-crash conditions, is currently under development within ETSI (see draft ETSI TR 102 892 V1.1.1_005 (2010-02) [7]).

3 COMPATIBILITY STUDIES

3.1 Compatibility studies (general aspects)

The frequency range 24-29 GHz (24.25-27.5 GHz) is designated to various radio applications according to the European Table of frequency allocations and utilisations in the frequency range 9 kHz to 3000 GHz (ERC Report 25 [8], Kyiv, October 2009). The results of the relevant compatibility studies are provided in the paragraphs below. The most challenging case was given by the Fixed Service in the band 24.5-29 GHz, which has therefore been studied in detail. However, specific compatibility studies between 26 GHz UWB SRR applications and fixed or mobile military systems within 26.5-27.5 GHz have not been carried out because of lack of data for military systems, especially for expected future military systems. The frequency band 26.5-27.5 GHz has been identified as a harmonised military band for fixed and mobile systems in ERC Report 25 and also in the NATO Joint civil/military Frequency Agreement (NJFA) 2002 ("harmonised NATO band type 2"). It was assumed that the results of the compatibility studies on the fixed service may be applicable for some of the military systems.

The protection of RAS in the band 23.6-24 GHz was not evaluated in detail, because of the following reasons:

- SRR will operate outside the relevant RAS frequency band (23.6-24 GHz)
- Decides 5 of ECC/DEC/(04)10 [2] for 24 GHz SRR provides a limit of -74 dBm/MHz within the band 23.6-24 GHz for the protection of RAS without a deactivation mechanism.

Therefore the emission limit of -74 dBm/MHz e.i.r.p. is assumed to be sufficient for protection of RAS.

Narrow-band radar systems within the band 24.05-24.25 GHz may be operated with 100 mW e.i.r.p. according to Annex 6 of ERC Recommendation 70-03 [9] (Radiodetermination applications). A harmonised regulatory solution allowing the use of band 24.05-24.25 GHz with maximum 100 mW e.i.r.p. and subject to the implementation of appropriate mitigation techniques to ensure coexistence with radar speed meter systems was also recently developed by CEPT and incorporated in Annex 5 of ERC Recommendation 70-03 (RTTT applications). The compatibility studies as described below are therefore limited to the band 24.25-24.5 GHz, which is only activated in specific driving conditions or in certain pre-crash conditions with an additional WLAM.

3.2 The impact of 26 GHz UWB SRR on the Fixed Service (FS)

3.2.1 Existing studies

It was agreed that the studies of ECC Report 023 [10] are still valid as the starting point for these investigations. These studies showed with 100% SRR market penetration that the protection objective of the Fixed Service can be exceeded up to 19 dB in aggregated scenarios (I/N = -1 dB).

The "single-car entry" scenario was not considered in ECC Report 023 but was later introduced in ITU-R Report SM.2057 [11]. This scenario was based on a "continuous stream of single cars" crossing a fixed link path. This scenario is on the one hand less critical than the aggregation scenarios in terms of exceeding the objective (max. 7dB, I/N=-13 dB), but would be on the other hand far more frequent because it is not strictly related to specific geographical situations, and might represent a major concern.

With these considerations the ECC Report 023 conclusions have been confirmed and in absence of new specific mitigations, 26 GHz UWB SRR according to ETSI TR 102 664 V1.1.1 with e.i.r.p. limits of -41.3 dBm/MHz mean e.i.r.p. and 0 dBm/50MHz peak e.i.r.p. will not offer long term coexistence with the Fixed Service. Therefore the revised limits provided in ETSI TR 102 664 V1.2.1 will be considered later in chapter 3.2.4 assuming its final approval will be agreed in by ETSI.

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[2] Decides 5 provides "that 24 GHz SRR systems transmitting in the band 23.6-24 GHz with an eirp higher than -74 dBm/MHz or in any band listed in considering ee) with an eirp higher than - 57 dBm/MHz, shall be fitted with an automatic deactivation mechanism to ensure protection of Radio Astronomy sites as well as manual deactivation to ensure that emissions are restricted only to those countries that have implemented the temporary solution. In order to allow an early implementation of 24 GHz SRR Systems the automatic deactivation shall be made mandatory from 1 July 2007. Before that date, manual deactivation is required."

3.2.2 Additional studies

A new study provided by one administration suggested there are scenarios, which may present more severe interference potential beyond those envisaged in the original ECC Report 023, which assumed that links shorter than about 2 km were not present.

The Monte-Carlo analysis provided shows that the expected worst aggregated impact of ECC Report 023 may be exceeded by further 7 dB if 3 SRR sensors are assumed to be in the line of sight on the first lane (ECC Report 023 uses 1 sensor in LOS while a second one was shadowed) and assuming a FS noise figure of 4dB (6dB was used ECC Report 023).
However, this case was worse than the assumptions in ECC Report 023 and did not receive general consensus.

The static analysis considers a very short FS link of 100 m in line of sight to a SRR sensor and shows that the impact is about 20dB higher than the single entry calculations of Report ITU- R SM.2057.

Another administration carried out an analysis to check the impact of SRR on BER performance of these FS links for 128 QAM transmissions (Rec. ITU-R F.1101 [12]) with the relevant FS link parameters assuming that the available fade margin will be available to mitigate interference from SRR. This administration is of the view that with a FS link fade margin of 10dB the BER performance will not be degraded, even for the very low Tx power values (-31 dBm) while with a FS link fade margin of 3dB the Link could be blocked by SRR. Another administration is of the view that it is generally not appropriate to assume that fade margins in fixed links are available for the purpose of mitigating interference as the fade margins are assigned to maintain the relevant performance and availability objectives for the appropriate propagation conditions.

It is recognised that very short range FS links may also be provided by other means (e.g. higher frequencies, optical links), but there is possibility to deploy such sort of links in a number of administrations. With regard to the short FS link there is a need to add the following clarifications:

- Most administrations include a minimum fade margin of 8 - 20 dB also in case where the actual rain induced “availability” objective (i.e. in term of Severely Errored Seconds, SES, or Blocks, SEB) would require less; this is retained necessary to ensure also that the link quality (i.e. in term of Errored Seconds, ES, or Blocks, EB) meets the required level. This fade margin is required to ensure link quality level and may not necessarily be available to mitigate interference. Furthermore some private spectrum licensees have proposed using lower fade margins. While this could result in lower quality links, this could be acceptable to some commercial customers and would permit higher densities of fixed link deployments.
- There are diverging views about available lowest Tx power of FS link equipment and the type of antenna used; one administrations is of the view that Tx power values assumed for this link (-31 and -37 dBm) are not practically available and consequently the desired 3dB link margin hardly practical; with -15 dBm (lowest transmit power available) the BER performance would not be impacted by the expected level of interference. In addition a large 60 cm antenna (42.7 dBi) was assumed in this scenario; with a more appropriate 30cm antenna with 37 dBi the impact would be reduced by about 6dB.

3.2.3 Geographical investigation in one country

One administration provided a study of geographical data on a large number of links (military systems omitted), as authorised under their national regulatory regime, in conjunction with surrounding terrain and major roads. This study showed that possible “critical” cases fitting the ECC Report 023 scenarios can be identified in a very limited number of cases in this country, and that the possible violation of the protection objectives (with ECC Report 023 assumptions) with the original limit proposed in ETSI TR 102 664 1.1.1 are possibly limited in this country to 5 dB only (I/N=-15 dB). However this can not be extended to other countries, which can have different geography and FS regulatory regimes and roads deployment customs. This analysis may represent additional confidence data with respect to ECC Report 023 conclusions in this country.

The impact of the revised limits provided in ETSI TR 102 664 V1.2.1 will be considered later in chapter 3.2.4.

3.2.4 Analysis about the impact of the proposed new limit on FS

Noting that the e.i.r.p. density limits provided by ECC/DEC/(04)10 are incompatible with FS, industry proposed new parameters for 26 GHz UWB SRR, which are contained in ETSI TR 102 664 V1.2.1 and shown in Table 1. This proposal has been based on typical Frequency Hopping (FH) SRR. Nevertheless, however, the proposed final limits are generally applicable and the silent gating period (Duty Cycle %) in any 50 MHz bandwidth can be satisfied either by FH SRR (emitting in different frequency slots during the silent periods) or by Pulse Position Modulation (PPM) SRR (actually stopping any emission during the silent periods). Table 1 along with some clarifying notes shows this new set of limits in comparison to the original proposal from the SRDoc.

Parameter	**Limit**	
Original limit proposal of the SRDoc ETSI TR 102 664 V.1.1.1		**Resulting mitigation compared to current regulation**
SRR Frequency Range	24-29 GHz (5 GHz)	The passive band is avoided
Mean e.i.r.p. @ 1MHz/ms	-41.3dBm/MHz	None
Peak e.i.r.p. @ 50MHz	0 dBm	None
Duty Cycle (DC)	No limit (up to 100%)	None
Revised limits proposed in draft ETSI TR 102 664 V.1.2.1 Note 1		**Resulting mitigation compared to current regulation**
SRR Frequency Range	24.25-27.5 GHz (3.25GHz)	The passive band is avoided and the overall bandwidth for SRR is reduced by 1.75 GHz
Peak e.i.r.p.	–7dBm/50MHz (for iBW≥50MHz) or –7dBm – 20*log(50MHz / iBW) measured with RBW = iBW (for iBW<50MHz)	7dB
Mean e.i.r.p. @ 1MHz/1s	-50 dBm/MHz	8.7 dB for mean power aggregation (Note 2) 10dB (DC=10%) to 17dB (DC=2%), in average, for peak power aggregation (additional to 7dB mitigation due to the peak power reduction) (Note 2)
Duty Cycle (DC)	2% to 10% per 50MHz and per sec	

Definitions:

DC = Ton/(Ton + Toff) % with:

Ton defined as the duration of a burst irrespective of the number of pulses contained.

Toff defined as the time interval between two consecutive bursts when the UWB emission is kept idle.

iBW = instantaneous bandwidth of each single pulse, defined to be the inverse of the pulse duration.

Note 1: The revised proposal takes account of the new study which has shown that the peak power interference increase would have more impact than an equivalent mean power interference increase. The benefit of a reduced Duty Cycle implies the burst-like nature of the SRR application; therefore a suitable burst limitation is proposed.

Note 2: This improvement has been theoretically calculated from the proposed Duty Cycle limitation and would further limit the possible worst case interference due to undesired peak impact on a wideband victim receiver.

Table 1: Proposed SRR parameters

3.2.5 Synchronisation loss considerations

The impact of interference from SRR into the FS will depend upon the level of both the mean and the maximum or peak e.i.r.p. This can affect the FS receiver in a number of ways, including an increase of BER and a possible loss of synchronisation.

The work undertaken to date within ECC has focussed on the increase in BER, mostly taking into account the mean power. Work undertaken has also noted that if there is a high peak to RMS ratio then the level of peak power can in addition impact the link performance.

In addition to this interference mechanism, there is the potential for the peak e.i.r.p. from an SRR burst to cause interference into FS receivers that could lead to synchronisation loss. This can occur when the C/(N+I) derived using the peak e.i.r.p. is significantly below the threshold required by the performance objectives. No studies have been undertaken within ECC as to at what point synchronisation loss would occur because the synchronisation mechanism is “implementation depending” and no definite rule can be drawn.

It is noted that a low Duty Cycle while maintaining average mean power would effectively increase the burst power and this would possibly increase the risk of synchronisation loss. Therefore a minimum Duty Cycle limit (2%) has also been introduced (see Table 1) to reduce the risk of synchronisation loss.

3.2.6 Performance and availability impact

The issue of further measurements has been considered. It was indicated that:

- Laboratory conducted measurements were already made in the past and are available in ECC Report 023.
- A contribution from one administration presented some “in field” interference tests, which confirmed the results of conducted measurement in ECC Report 023 and fit the theoretical background.

Therefore no need for additional measurements was identified.

Theoretical simulations of the BER behaviour on an ideal FS receiver have been made based on specific combination of the peak and mean e.i.r.p. permitted within the flexibility of the new limit proposal; both single car entry and aggregation situation similar to those identified with “all scenarios” and “most scenarios” in the conclusions of ECC Report 023 were considered in comparison with the original limits of ECC/DEC/(04)10.

3.2.7 Other considerations

ECC Report 023 assumed 100% long term market penetration. It has been proposed by some SRR industry that a maximum 40% penetration of cars is to be assumed for SRR at 26 GHz due to the alternative technologies already on the market. However it is difficult to quantify the long term figure and how this could be translated into given sharing scenarios for interference assessment purposes to other services.

Similar to the existing ECC/DEC/(04)10, where the market penetration is limited to 7%, such a limitation could be envisaged also for the new proposal. Therefore a value of 10% is considered later.

In addition, data obtained over one manufacturer’s typical production of 24 GHz UWB SRR showed that the aggregated impact may be expected to be further reduced when considering that the RMS and peak e.i.r.p of an SRR sensor, for “legally” meeting the regulatory level (e.g. presently -41.3dBm/MHz) required in the relevant Harmonised Standard, may be on average about 2.5dB below the limit.

3.2.8 Conclusions

The analysis, based on the current provisional e.i.r.p. density limits provided by ECC/DEC/(04)10, have confirmed the potential incompatibility with FS in the affected bands.

The analysis of the revised limits proposed in Table 1 (still in the light of the scenarios described in ECC Report 023 and “single-car entry”) has shown that:

1) The substantial reduction of the peak power significantly reduces the amount of performance degradation of the FS victim receiver even when the mean power I/N objectives are slightly exceeded.

2) In the “single-car”[3] scenario, considering the DC improvement over the BER (averaged for 1 second according the ITU recommendations), the estimated degradation of the BER threshold (~0.05 dB) is considered to be within the objectives (degradation of the ITU error performance and availability objectives 0.5% to 1%). The most severe “instantaneous” BER degradation, which occurs with the minimum DC, appears to be within a range manageable by typical FS demodulator without risk of loss of synchronisation.

3) In the “most scenario” [4] aggregated conditions, the estimated degradation of the BER threshold is ~0.2 dB which is equivalent to an availability objective degradation of about 3.5 % to 6 % depending on the link length, rain rate and availability objectives.

4) In the “all scenario” [3] aggregated conditions, the estimated degradation of the BER threshold is ~2.5 dB which is equivalent to an availability objective degradation of about 50% to 120% depending on the link length, rain rate and availability objectives. This is still significantly exceeding the objectives. Nevertheless, also due to the reduced peak power impact, when compared with the expected BER threshold degradations with the original 24 GHz SRR characteristics, the improvement is about 13 dB.

5) When a 10% market penetration of 26 GHz UWB SRR would be ,assumed, the aggregation impact of the proposed new limit would be ~10 dB lower than mentioned above in 3) and 4) and with this the degradation would be as follows:

   - The “most scenarios” conditions would be reduced to 0.02 dB BER threshold degradation and an availability objective degradation of less than 0.5% in any link conditions.
   - The “all scenarios” conditions would be reduced to 0.2 dB BER threshold degradation and an availability objective degradation of about 3.5% to 6% depending on the link length, rain rate and availability objectives. An availability degradation of 6% corresponds to an increase of the unavailability of about 3 minutes per average year for a FS link planned with an availability of 99.99%.

6) The above conclusions for the aggregated scenarios should be considered together with all other mitigations (e.g. production spreads, geographical occurrence probability, etc...).

   - If a value of 2.5 dB is considered for the production spread in the “all scenarios” conditions together with a reduction of the market penetration to 10% the BER threshold degradation would be about 0.11 dB with an availability objective degradation of about 3%. An availability degradation of 3% corresponds to an increase of the unavailability of about 1.5 minutes per average year for a FS link planned with an availability of 99.99%.
   - According to an analysis of one administration on their deployment of a large number of FS links in the band 24-29 GHz, the impact is less than assumed above and with this no interference would be expected within that administration. However, it has been considered that the geographical situation in one country is not representative of other countries, which may have different deployment rules for FS links in these bands.

7) For the “additional studies” reported in section 3.2.2, outside ECC Report 023 assumptions, the estimated degradation in term of fade margin loss might be more significant, but its conversion into actual “error performance and availability degradation” is more complex because such shorter hops in these frequency bands may bring new technical elements into consideration. Some administrations are of the view that such FS links (e.g. Tx power values less then -31 dBm and a link margin of 3dB) are not realistic. Other administrations reported the deployment of short links in their country and therefore they are concerned with the deployment of SRR on their territory.

In conclusion compatibility studies on the impact of the 26 GHz UWB SRR on the Fixed Service show that the limitation of the SRR penetration rate to about 10% may be considered in order to allow the deployment of 26 GHz UWB SRR with the new limit proposal given in Table 1.

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[3] The single car scenario is based on Report ITU- R SM.2057.

[4] From ECC Report 023:

“*However, on the basis of the whole range of calculation results, it can be concluded that with an e.i.r.p. density of -60 dBm/MHz the FS protection criteria (–20 dB I/N) for* ***all scenarios*** *considered in these studies is respected, whilst with an e.i.r.p. density of –50 dBm/MHz, this protection criteria would be met in* ***most scenarios****. Some administrations are of the opinion that is it necessary that SRR meets the –20 dB I/N protection criteria in all cases. Some other administrations are of the opinion that an excess of the protection criteria by 10 dB, which still corresponds to an I/N of –10 dB, is acceptable.*”

When the new limits (-50 dBm/MHz) are applied, this consideration would correspond to: I/N = -10dB for **all scenarios** and I/N = -20dB for **most scenarios**. However the simulations made for this study have also considered a combination of the peak and mean e.i.r.p. permitted within the flexibility of the new limit proposal, while ECC Report 23 considered only the mean power effect.

3.3 The impact of 26 GHz UWB SRR on EESS (passive) and Space Research Service (Space to Earth)

The compatibility analysis which has been conducted addressed the protection of EESS and SRS space earth stations from 26 GHz UWB SRR emissions, including those in the passive band 23.6-24 GHz.

Concerning the protection of EESS and SRS space earth stations, based on an exhaustive list of earth stations deployed within Europe, the analysis of the new limit proposal, as contained in Table 1, concluded that the expected benefit in terms of the mean power aggregation scenarios is 9 dB (based on a mean power of -50 dBm/MHz/s). In that case, an average mean power of -50 dBm/MHz implies that compatibility is achieved for EESS and SRS, space earth stations.

Concerning the protection of the purely passive band 23.6-24 GHz, the meeting agreed with the following limits applicable to SRR, even without any Duty Cycle:

a) Direct emission limit in the main beam will not exceed -73 dBm/MHz e.i.r.p.

b) Additional average antenna attenuation above 30° elevation to be separately measured will be at least 20 dB.

3.4 26 GHz UWB SRR conclusions

The limits presented in Table 2 are proposed for 26 GHz UWB SRR to ensure compatible operation with radio services:

SRR Frequency Range	24.25-27.5 GHz (3.25GHz)
Peak e.i.r.p.	–7dBm/50MHz (for iBW≥50MHz) or –7dBm – 20*log(50MHz / iBW) measured with RBW = iBW (for iBW<50MHz)
Mean e.i.r.p. @ 1MHz/1s	-50 dBm/MHz
Duty Cycle (DC)	2% to 10% per 50MHz and per sec
Additional limits in the band 23.6-24 GHz	Direct emission limit in the main beam : -74 dBm/MHz e.i.r.p.
	Additional average antenna attenuation above 30° elevation: 20 dB.
SRR maximum penetration rate	10%

Table 2

3.5 WLAM

The purpose of WLAM proposed to operate in the extended 24.05-24.5 GHz is to improve system performance in driving situations which are critical for pedestrian safety and where additional performance is required. The use of a wider bandwidth is minimized by activating WLAM only in specific car configurations (emergency braking or rear parking).

The technical parameters for WLAM are under consideration within ETSI through the development of a system reference document for SRD radar equipment using WLAM (draft ETSI TR 102 892 V1.1.1_005). The development of this SRDoc will account for the initial compatibility results already achieved in the framework of the EC Mandate.

The compatibility studies consider a number of aspects relating to the WLAM activation modes which have been defined as follows:

- WLAM calibration mode: a permanent mode which is using a few low power CW tones with a -8 dBm e.i.r.p . The duty cycle is 1%/s for the tones emitting above 24.25 GHz

- WLAM front driving mode (APPS): a very-low activity mode only activated for active braking and pedestrian detection support using a front camera system as a primary sensor, which is using a modulated frequency, with a +20 dBm e.i.r.p.

- WLAM rear-parking mode: a low activity mode using a modulated frequency, with a +20dBm e.i.r.p , activated only when the vehicle moves back during a parking maneuver to better detect pedestrians. The average activity factor for each car is about 0.01% per day.

A number of compatibility studies are under development:

- Calibration mode versus "traditional" P-P fixed links: the deployment of such links in the frequency range 24.05 and 24.5 GHz seems to be limited and is expected to be restricted to ENG/OB applications. In addition, according to the information which was made available and as indicated in EFIS, only 7 administrations have identified the band between 24.05 and 24.5 GHz for SAP/SAB and ENG/OB. This scenario considers both single entry and aggregated cases. The compatibility studies relating to this scenario are still under development however it was noted that the sharing conditions with ENG/OB are more favourable than with the "traditional" P-P fixed links.

- WLAM front driving mode for active braking and pedestrian detection support: the activity factor has been estimated to 0.03 s/km/year based on the 2.2 s activation duration and the probability to have an accident with a pedestrian over a 1 km road portion, therefore, it is expected that the interference cases will be very seldom. At this stage, no additional study is considered needed for this case.

- WLAM rear parking mode versus ENG/OB link: the preliminary studies indicated that a single WLAM APPS or parking mode with +20 dBm e.i.r.p emitting towards a ENG/OB link would likely lead to harmful BER degradations and a possible synchronisation loss. Again, the deployment of the ENG/OB links would need to be further considered in order to reach conclusions on the compatibility. In addition, some parameters such as the shadowing, low activity factor, density of car effect would also need to be further studied… It must also be noted the mobile services, such as cordless cameras, have severe line of sight issues at such a high frequency since they are planed to be used for in-door applications (television studio) or on a football stadium (12 GHz cameras today) where the environment is strictly under control.

It is expected that the final results of the compatibility studies relating to WLAM will be retained in an ECC Report.

For the protection of the passive services in the band 23.6-24 GHz limits consistent with the proposed limits for SRR (see section 3.3) are under consideration.

4 ASSESSMENT OF THE AUTOMOTIVE SHORT-RANGE RADAR SECTOR

An assessment of the automotive short range radar sector is given in Annex 2 to this CEPT Report. It describes in detail current market situations for automotive radar applications and the foreseen implications of different regulatory options towards future deployment of road safety applications.

Road Safety is of great importance. It has been commonly agreed for many years among the EU member states and the European Commission that Advanced Driver Assistance Systems are indispensable in order to support the European Road Safety Programme (4^{th} eSafety Programme and the Action Plan for the Deployment of Intelligent Transport Systems in Europe – ITS Action plan). According to different EU studies, it has to be assumed that systems based on radar technology will reduce the number of traffic accidents by about 20% (ref.: e-Impact, SEiSS, TRACE).

The three different regulatory options analysed in this assessment study on SRR are quoted below:

- Option A: keep current regulatory framework as it is / no change
- Option B: SRR systems in a portion of the frequency band 24-29 GHz (26 GHz UWB SRR)
- Option C: 24 GHz narrow-band (NB) radar systems with extended band mode (WLAM)

Options B and C are not mutually exclusive.

The results of the responses to the Commission's call to the stakeholders and also to a questionnaire from CEPT as well as the information coming from other available sources were considered within the frame of this assessment.

In response to the question whether any alternative bands are to be considered for automotive short-range radar systems, the assessment of the automotive short-range radars highlights a broad convergence of views on the mid to long term technology choice for SRR. Indeed 79 GHz UWB SRR is recognised to be the most favourable technology both from a technical and regulatory point of view. It is also recognised that, while the semiconductor technology for 79 GHz is now available, system integration and validation of 79 GHz UWB products may not in general be possible in time for a seamless transition in 2013.

However, today there is a strong disagreement on how to reach mass market deployment for UWB SRR.

Some administrations and industry stakeholders consider that, in order to prevent that an important contribution to road safety that can save human lives will not be available for several years in case of a technology gap, an alternative/interim solution is needed. SRR systems working between 24.25 and 27.50 GHz could fill this gap as the existing 24 GHz technology can be easily adjusted. They observe that 26 GHz UWB SRR would be readily available as a replacement for 24 GHz UWB SRR at the cut off date of 2013 to keep UWB SRR in the cars. They conclude that these systems should be allowed as long as they are compatible with other radio applications. They support the principles of technology neutrality, competition and widest choice of spectrum options for automotive safety applications. They also consider that 79 GHz UWB SRR will not be ready for integration in vehicle product line by 2013 and expect that the use of 26 GHz technology will accelerate the deployment of the 79 GHz sensors due to the fact that automotive applications are already available for the customer and create an increasing demand for UWB SRR. In consequence the market for UWB SRR would expand faster, also because 26 GHz sensors could also be used in the United States and in Japan (see regulations detailed in Annex 2). Without the availability of 26 GHz UWB sensors, the companies which have been using 24 GHz UWB sensors since 2005 (which are also the technology drivers for UWB SRR including 79 GHz) will be forced to switch to other technologies different from UWB SRR. As a consequence, UWB SRR will be designed out of their cars. This means the proven safety benefits of UWB SRR will be substantially decreased for all UWB technology from their point of view. In addition, the market acceptance and deployment of 79 GHz UWB SRR would be seriously delayed.

Other administrations and industry stakeholders are of the opinion that no additional frequency band should be made available for UWB SRR systems on the sole argument of possible compatibility. While recognising the need for technical neutrality on a band by band basis, there are other considerations such as the need to protect future spectrum use. Assessing compatibility for a service where the nature of its future deployment is difficult to predict is no easy matter, particularly across such a wide bandwidth and where personal safety considerations need to be taken into account. These administrations and industry stakeholders argue that the existing 24 GHz arrangements set out by Decision ECC/DEC/(04)10 and subsequently confirmed by EC Decision 2005/50/EC, have established a market which would be distorted by opening up an additional band some six years later. In view of this, these administrations and stakeholders consider that the difficulties faced by those companies which have implemented 24 GHz UWB SRR should not be resolved by the designation of a new frequency band at 26 GHz for UWB SRR systems. They consider that allowing 26 GHz UWB SRR will result in market fragmentation for UWB SRR sensors and affect manufacturers and suppliers which have focused on developing UWB SRR technology for operation in the 79 GHz range, which has been identified by CEPT in 2004, and subsequently confirmed by EC Decision 2004/545/EC, as the most suitable band for long term development and deployment of automotive short-range radars. The designation of a new frequency band for UWB SRR systems could delay the development and subsequent deployment of this technology to well beyond 2013 and reduce the possibility of achieving the desired road safety benefits. During the public consultation of the CEPT Report 36, it was also observed by one respondent that the sensor based on 76 GHz/79 GHz technology is available and is in the course of validation within the responding car manufacturers. According to this respondent this validation will be ended before the deadline of the 1st July, 2013. They also consider there is solid evidence that production in car lines could start extensively within the time frame 2014/2017 and recognize that the regulatory measures in Japan for enabling 26 GHz UWB SRR systems have been in force since 20 April 2010 (see regulations detailed in Annex 2).

Finally, the proposal for an enhancement (WLAM) of existing 24 GHz narrow-band radar technology to address some critical “pedestrian protection” scenarios is seen as being complementary to existing regulations for automotive radar applications. Concerns have been raised however on potential adverse impact on the market of UWB SRR.

5 CONCLUSIONS

5.1 Results of compatibility studies on possible alternative bands for automotive short-range radar systems

CEPT was mandated to propose appropriate technical and regulatory measures for alternative bands to ensure the protection of existing radio services in or near any such bands (part 2 of the Mandate). Two alternative solutions have been considered. The results of compatibility studies are provided in section 5.1.1 and 5.1.2 below.

5.1.1 26 GHz UWB SRR (24.25-27.5 GHz)

In conclusion the limitation of the SRR penetration rate to about 10% may be considered in order to allow the deployment of 26 GHz UWB SRR with the new limit proposal given in Table 2 of section 3.4.

5.1.2 Narrow-band radars (24.05-24.25 GHz) with additional WLAM (24.25-24.50 GHz)

The technical parameters for WLAM are under consideration within ETSI through the development of a system reference document for SRD radar equipment using WLAM (draft ETSI TR 102 892 V1.1.1_005). The development of this SRDoc will account for the initial compatibility results already achieved in the framework of the EC Mandate.

The compatibility studies with the Fixed Service are considering a number of aspects relating to the WLAM activation modes and these studies are still under development. It is expected that the final results of the compatibility studies relating to WLAM will be retained in an ECC Report.

Information on the characteristics and use cases of ENG/OB systems operating in the band 24.25-24.5GHz is still needed to complete the compatibility studies.

For the protection of the passive services in the band 23.6-24 GHz limits consistent with the proposed limits for SRR (see section 3.3) are expected to be applied.

5.2 Consideration of possible technical and regulatory measures for alternative bands for automotive short-range radar systems

5.2.1 UWB SRR systems

5.2.1.1 Regulation for 26 GHz UWB SRR (24.25-27.5 GHz) without a specific time limitation

The technical elements for a possible new regulation designating the frequency band 24.25-27.50 GHz for automotive SRR systems are given in table 2 of this Report (see section 3.4).

Considerations in favour of allowing 26 GHz UWB SRR:

SARA, supported by a few administrations, asks for 26 GHz UWB SRR systems to be allowed as a replacement for 24 GHz UWB SRR because 79 GHz UWB SRR will not be ready for putting on the market by 2013. They consider that the designation of the alternative frequency band at 26 GHz (24.25-27.5 GHz) for UWB SRR systems is possible based on the parameters as described in table 2 of section 3.4 and by taking into account that the 79 GHz frequency range has been identified by CEPT and by the EC as the most suitable band for the long-term and permanent deployment of UWB SRR systems. The relevant parameters also contain a maximum penetration rate which ensures that the 26 GHz band for SRR UWB will not be a long term solution and cannot jeopardize the most suitable 79 GHz frequency band.

The compatibility studies have shown that coexistence with the relevant radio applications is provided by taking into account the parameters and mitigation requirements for UWB SRR as described in table 2 of section 3.4 and therefore a cut off date for the designation of the band 24.25-27.5 GHz for UWB SRR would not be justified. It has also to be considered that a cut-off date would constrain the market development for 26 GHz UWB SRR which was obviously the case for the 24 GHz UWB SRRs. Therefore the designation of the band 24.25-27.5 GHz should preferably not be limited in time. An early deployment of the 26 GHz products would bridge the technology gap between the sunset date for 24 GHz based systems and the market introduction for 79 GHz based systems and should not unduly be constrained by measures which are not justified from a frequency management point of view. Also the principles of competition, non-discriminatory regulation and technology neutrality should be taken into account. At the end the SRR market should decide at which point of time the transfer from 26 GHz to 79 GHz for UWB SRR will take place.

These administrations consider that keeping the current framework as it is, with no change (i.e. as per “Option A” defined in this report) is unjustified. Competition between 26 GHz and 79 GHz sectors will bring cost down and make vehicle applications based on UWB SRR affordable for broad market segments, which supports the desired road safety benefits.

It has been discussed during the development of this Report what kind of impact could be caused on the market by making available one or more regulatory solutions in addition to the long term solution at 79 GHz. Those supporting additional solutions indicated that the market would benefit from those solutions. Different frequency bands / systems can be made available for the same purpose as long as interoperability between them is not required. Market fragmentation has to be understood in relation to missing interoperability between network components. The UWB SRR systems implemented in cars cannot be considered as network components. Every UWB SRR system inside a car has to be considered as a closed communication system (sensor - chipset - driver), interoperability between systems of different cars is not in question.

Therefore for those radio applications, e.g. UWB SRR; market fragmentation cannot be caused by making available different options (frequency bands, techniques). Hence the products for the 24 GHz (narrow-band radars with WLAM), 26 GHz and 79 GHz bands may provide different levels of quality and will be available on the market for the implementation at different point of times for different customers. This is not at all against the aims of European harmonisation. In addition different frequency bands / alternative solutions support the competition which would result in the fact that the market for 26 GHz as well as for 79 GHz UWB SRR will develop faster. This will also be beneficial for road safety.

These administrations consider that the proposal of a new frequency band at 26 GHz is in line with ECC Decision (04)10 which states in considering-w, that after June 2013, the 79 GHz band or any other technical solutions should be used. It is based on the need for harmonisation with the US and Japanese regulation forcing this frequency shift.

Considerations against allowing 26 GHz UWB SRR:

A majority of administrations do not support the designation of a new frequency band at 26 GHz for UWB SRR systems (i.e. as per "Option B") that is likely to jeopardise efforts of vehicle manufacturers and suppliers which have focused on developing UWB SRR technology for operation in the 79 GHz frequency range, in accordance with initial EC and ECC Decisions. In addition, this situation will sent a wrong message to these vehicle manufacturers and suppliers, will delay the development and subsequently deployment of this technology to well beyond 2013.

Some vehicle manufacturers and suppliers who have invested in the 79 GHz UWB SRR are of the same opinion as these administrations who consider that allowing 26 GHz UWB SRR will result in market fragmentation of UWB SRR sensors used for the same application. Moreover, this is against the interest to preserve spectrum for other use. The consequence of that is reduction in the potential mass market, which will increase the cost of 79 GHz UWB SRR sensors with regard to the cost planned at present time. This will exclude volume car makers to equip whole range of vehicle with these safety applications The 79 GHz frequency band itself will provide a competitive environment for SRR systems with different technological choices followed by stakeholders and will be amplified with a 79 GHz UWB worldwide harmonisation that is expected by all. Moreover, endeavours in technology particularly for packaging and function integration will open the industrialisation business to new comers allowing strong competition and cost reduction. Opening a new frequency band will reduce the possibility of achieving the desired road safety benefits. They also argue that vehicle manufacturers and suppliers which have focused in the 79 GHz UWB SRR will not be able to provide safety applications operating in the 26 GHz UWB frequency band because the solution between 79 GHz UWB and 26 GHz UWB are not interchangeable.

The assessment on SRR performed within the framework of this Mandate confirms the 79 GHz frequency band as the most favourable solution both from a technical and regulatory point of view, consistently with European strategy for promoting Collective Use of Spectrum above 40 GHz identified in the ECC strategic plan reviewed by ECC in March 2010 as a major challenge for the next five years. The assessment on SRR shows also that production in car lines could start within the time frame 2014/2017.

Finally, it is a widespread misunderstanding that technology neutrality means frequency neutrality i.e. that all possible frequency bands should be designated for a given application. Frequency management involves making decisions on the use of bands and technology neutrality implies that the decision on the technology to be used in a frequency band is left to those seeking to use spectrum. For example, the decision taken by the EC to allocate the 79 GHz band for permanent use for automotive radar means a market has been opened within which a technical neutral competition between vehicle manufacturers and suppliers can take place. If the 79 GHz automotive frequency band becomes available on a worldwide basis then this will accelerate the transition from other frequency bands.

5.2.1.2 Time limitation (cut-off date) for 26 GHz UWB SRR

Although the technical studies are suggesting that the compatibility with radio services could be achieved without consideration of any time limit (see section 3), a time limitation, if sufficiently ahead in time, can meet the present market requirements. This would restrict the deployment of 26 GHz sensors.

However, it is also argued that the opening on a temporary basis of the 26 GHz frequency band for UWB SRR systems would encourage a global new market against the European solution at 79 GHz, with the same potential adverse effects as under a permanent arrangement.

5.2.1.3 Proposal for extending the 24 GHz UWB SRR agreement

While there is no sufficient support within CEPT for opening a new frequency band for UWB SRR systems that would encourage a global new market against the European solution at 79 GHz, some administrations are of the opinion that a transition to 79 GHz can be facilitated by extending the existing 24 GHz agreement but with some modifications to the terms of that agreement. This proposal would enable vehicle manufacturers which have already implemented 24 GHz UWB SRR in existing vehicle product lines to equip new vehicle model at 24 GHz in the short term.

This proposal would basically allow the production in 24 GHz to continue beyond 1/7/2013. An extension of the cut-off date (currently 2013) would be offered in order to cope with the perceived "technology gap" and consequently facilitate transition to the permanent 79 GHz band.

The regulatory implications of this strategy regarding the current interim solution (24 GHz) would be limited and vehicle manufacturers could focus on the 79 GHz frequency band for the introduction of UWB SRR systems on a large scale basis and long term basis.

The possible provisions of the proposed "extended transition solution for 24 GHz UWB SRR systems" are given by:
- 1. Max penetration rate 0.2 %
- 2. Cut-off date 2018 (i.e. an extension with a maximum of 5 years)
- 3. New Vehicle models not allowed to be equipped with 24 GHz UWB SRR systems after 1/7/2013;

The first limit (1. or 2.) reached will put a stop for putting new 24 GHz UWB SRR systems on the market.

Details of the proposal are given in **Annex 3**. These are the only exceptions to the conditions provided by ECC/DEC/(04)10 (amended Sep 5, 2007).

Some Administrations are opposed to such extension of the 24 GHz UWB SRR agreement, since it would go over a global compromise agreement reached in ECC/DEC/(04)10. It is also observed that no automotive company supports a prolongation of the 24 GHz approach, there is no demand for this approach and industry stakeholders consider that this alternative is not useable.

The scientific community (ESA-EUMETSAT-EUMETNET-CRAF) also expressed serious concerns about this solution and strongly opposed this 24 GHz UWB SRR extension, in particular since it would represent a new breach in the imperious protection of this essential frequency band covered by RR N° **5.340**. To this respect, these organisations highlight the fact that, whatever the conditions and date of this extension, it would be in total contradiction with RSPG Opinion on "**a Coordinated EU Spectrum Approach for Scientific Use of Radio Spectrum**" and in particular its provision 9.5", stating:

> *"The RSPG considers that these represent essential natural resources and urges Member States to respect their obligations under No. 5.340 of the Radio Regulations, which prohibits all emissions in the corresponding frequency bands. The RSPG recommends the EC, when preparing appropriate measures on spectrum, to support the needs of the scientific services in these particular bands."*

Last but not least, ESA-EUMETSAT-EUMETNET-CRAF do not understand how such cut-off date extension of 24 GHz UWB SRR could be considered, that would obviously lead to an incompatibility between SRR and passive sensing when on the other hand compatibility exists in the 26 GHz with all allocated services as outlined in the present CEPT Report 37. Thus there would be no rational reason for favouring an extension of the 24 GHz SRR use over a 26 GHz SRR temporary solution for the same period of time.

5.2.2 Narrow-band radars (24.05-24.25 GHz) with additional WLAM (24.25-24.50 GHz)

CEPT considers it is still premature to envisage a regulatory measure for WLAM.

The delivery of an ETSI SRDoc which was recently announced by ETSI would support preparing a more consensual regulatory proposal.

Therefore CEPT has concluded to finalise this work outside the scope of the EC Mandate on SRR. Consideration of a new frequency band (24.25-24.50 GHz) for incorporation in Annex 5 of ERC/REC 70-03 would allow developing a stable regulation which could then be proposed, in a final step, for insertion in the Commission Decision on SRDs.

It should be noted that WLAM is not a substitute for UWB SRR but would compete with UWB SRR for some of the applications supported by UWB SRR.

ANNEX 1: EC MANDATE ON SRR

EUROPEAN COMMISSION
Information Society and Media Directorate-General

Electronic Communications Policy
Radio Spectrum Policy

Brussels, 7 November 2008
DG INFSO/B4

RSCOM08-81 Final

PUBLIC

RADIO SPECTRUM COMMITTEE

Working Document

Opinion of the RSC
pursuant to Article 4.2 of Radio Spectrum Decision 676/2002/EC

Subject: **Final and adopted Mandate to CEPT to undertake Technical studies on automotive short-range radar systems (SRR)**

This is a Committee working document which does not necessarily reflect the official position of the Commission. No inferences should be drawn from this document as to the precise form or content of future measures to be submitted by the Commission. The Commission accepts no responsibility or liability whatsoever with regard to any information or data referred to in this document.

MANDATE TO CEPT
TO UNDERTAKE TECHNICAL STUDIES ON AUTOMOTIVE SHORT-RANGE RADAR SYSTEMS (SRR)

Title

A mandate to CEPT ("SRR Mandate 2") to undertake radio compatibility studies in support of the fundamental review of EC ;Decision 2005/50/EC on the harmonisation of the 24 GHz range radio spectrum band for the time-limited use by automotive short-range radar equipment in the Community, and to undertake radio compatibility studies with regard to possible alternative approaches.

Purpose

Pursuant to Art. 4 of the Radio Spectrum Decision, CEPT is mandated to undertake all necessary technical work to support the fundamental review of the 24 GHz Decision[5] and to undertake technical studies in alternative bands for SRR applications. The results may be used to optimise the current radio spectrum regulatory framework for automotive short-range radar applications, including the possibility of identifying alternative spectrum for them.

Justification

Automotive SRR systems have been identified by the EU policy initiative *eSafety*[6] as a significant technology for the improvement of road safety in Europe by active means, and as one of a number of active and passive measures that could be introduced together to address the overall transport policy goal of reducing road fatalities in Europe.

The achievement of this policy goal would be supported inter alia by a significant take-up of effective SRR technology in the European automotive market, which would benefit from access to satisfactory radio spectrum resources harmonised throughout the EU.

Background

The radio spectrum framework for the introduction of automotive SRR technology in the European Union was set by the adoption of two Commission Decisions. The first, on 79 GHz (i.e. 77-81 GHz), providing a permanent band for SRR applications, was adopted on July 8th, 2004. The second, using 24 GHz (i.e. 21.65-26.65 GHz), as a temporary spectrum band, was adopted on January 17th, 2005. The technical basis for both Decisions was provided by CEPT pursuant to an EC mandate on SRR agreed by the Radio Spectrum Committee in June 2003[7].

The 24 GHz Decision stipulates that a fundamental review of the Decision would be carried out by 31 December 2009 at the latest to verify the continuing relevance of the initial assumptions concerning the operation of automotive short-range radar in the 24 GHz range radio spectrum band.

In addition, alternative bands in the 24-29 GHz range have been proposed by automotive interests for the operation of short-range radar, with a view to avoid compatibility problems with the passive radio services before moving to the 79 GHz band.

In the frame of the review, an initial Call for Input from stakeholders is foreseen. The results of such a Call will be transmitted to CEPT by the Commission following its conclusion (end of 2008) and should be taken into account.

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[5] Article 5.2 of the Decision states:*"... a fundamental review shall be carried out by 31 December 2009 at the latest to verify the continuing relevance of the initial assumptions concerning the operation of automotive short-range radar in the 24 GHz range radio spectrum band, as well as to verify whether the development of automotive short-range radar technology in the 79 GHz range is progressing in such a way as to ensure that automotive short-range radar applications operating in this radio spectrum band will be readily available by 1 July 2013."*

[6] see http://europa.eu.int/information_society/programmes/esafety/index_en.htm

[7] Mandate to CEPT to harmonise Radio Spectrum to facilitate a coordinated EU Introduction of Automotive Short-Range Radar (SRR) Systems

Order and Schedule

1. The CEPT is hereby mandated to undertake all relevant technical work to support the review of the 24 GHz EC Decision on SRR (part 1) and to undertake studies with regard to alternative approaches to the 24 GHz range for SRR use (part 2). The Commission’s Joint Research Centre may be able to provide reference measurements where relevant in support of SRR interference studies.

2. More specifically, CEPT is mandated to:

Part 1

- consider the continuing relevance of the initial technical assumptions concerning the operation of automotive short-range radar in the 24 GHz range. All necessary technical compatibility studies between automotive SRR systems and other radio services should be undertaken, re-using or confirming the results of previous studies where still relevant[8] ;

- consider the development of the automotive SRR technology in the 79 GHz range and report on whether there are any technical barriers to the uptake of the 79 GHz band as the permanent band for automotive SRR in the medium term;

- consider in its work the results of the Commission's Call to stakeholders for Input on the fundamental review.

Part 2

- 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;

- consider in its work the results of the Commission's Call to stakeholders for Input on the fundamental review.

CEPT is expected to summarise the results on the above-mentioned tasks in a report to the Commission.

3. The CEPT is mandated to provide Mandate deliverables according to the following schedule:

Delivery date	Deliverable	Subject
March 2009	Intermediate Report from CEPT to the Commission on Part 1 of the mandate	Description of initial work undertaken under Part 1 of this Mandate and orientation for future work
October 2009*	Final Report from CEPT to the Commission on Part 1 of the mandate Intermediate Report from CEPT to the Commission on Part 2 of the mandate	Description of work undertaken and results achieved under Part 1 of this Mandate Description of initial work undertaken under Part 2 of this Mandate and orientation for future work
March 2010*	Final Report from CEPT to the Commission on Part 2 of the mandate	Description of work undertaken and results achieved under Part 2 of this Mandate

* subject to subsequent public consultation

4. The result of this Mandate can be made applicable in the European Community pursuant to Article 4 of the Radio Spectrum Decision[9].

In implementing this Mandate, the CEPT shall, where relevant, take the utmost account of Community law applicable.

***

[8] Notably the CEPT Report to the EC under the SRR Mandate (see doc. RSCOM 04-41 of September 15th 2004).

[9] Decision 676/2002/EC of the European Parliament and of the Council of 7 March 2002 on a regulatory framework for radio spectrum policy in the European Community, OJ L 108 of 24.4.2002, p.1.

ANNEX 2: ASSESSMENT OF THE AUTOMOTIVE SHORT-RANGE RADAR SECTOR

STAGE 1 - IDENTIFICATION/DESCRIPTION OF THE PROBLEM(S)

In 2004, two frequency bands were identified for the introduction of automotive UWB SRR (Short Range Radar) technology in Europe:

- the 24 GHz frequency range (i.e. 21.65-26.65 GHz), as a temporary band for UWB SRR systems (24 GHz UWB SRR)
- the 79 GHz frequency range (i.e. 77-81 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 on the 24 GHz frequency range stipulates that a fundamental review of the Decision should be carried out by 31 December 2009.

Draft CEPT Report 36 was approved, subject to public consultation, by the ECC at its meeting in October 2009 in response to Part 1 of the EC mandate on SRR ("SRR Mandate 2"). It concludes in particular the following:

- existing regulation for UWB SRR in the 24 GHz frequency range should not be modified;
- while the semiconductor technology for 79 GHz is now available, system integration and validation of 79 GHz UWB products may not be possible in time for a seamless transition in 2013.

This assessment of the automotive short range radar sector ("the assessment") falls within Part 2 of the 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 relevant compatibility studies performed within WGSE Project Team SE24.

STAGE 2 - DESCRIBE THE POLICY ISSUE AND IDENTIFY THE OBJECTIVES

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 EU25 roads every year, resulting from 1.4 million accidents, with an equivalent cost of around €200bn/year, or 2% of EU GDP.

Road safety policies can rely on various initiatives, including SRR, which is described in ETSI TR 102 664 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 ETSI TR 102 664, 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 percent of all traffic accidents are the result of rear-end collisions. Reducing these accidents by 20 percent and additionally reducing the severity of an even higher percentage, would be a milestone in improving automotive safety.

This assessment does not intend to compare the merits of SRR or alternative technologies with other road safety policy initiatives. It rather concentrates (a) on possible regulatory measures to facilitate the development of active safety systems enabling the mitigation and the avoidance of collision and (b) on the assessment of the impact of these systems.

Different regulatory options need to be identified and analysed to achieve the policy objective:
Achieving the safety benefits of collision mitigation and avoidance applications while minimizing the costs associated with designating spectrum for these applications.

STAGE 3 - IDENTIFY AND DESCRIBE THE REGULATORY OPTIONS

Three different options are identified below. It should be noted that these various options do not challenge the merit of existing regulation for 79 GHz UWB SRR, which is already well emphasized in CEPT Report 36 developed in response to Part 1 of the EC Mandate on SRR. Consideration may instead be given on the possible impact of these various scenarios on the further development of 79 GHz UWB SRR.

It should be noted that these options are not necessarily mutually exclusive.

The option of a timescale extension for SRR in the frequency band 21.65-26.65 GHz (24 GHz UWB SRR) is not explored in this assessment as ECC concluded in CEPT Report 36 that existing regulation for 24 GHz UWB SRR systems should not be modified. In particular, no new 24 GHz UWB SRR systems can be placed on the European market after the cut-off date of 1st July 2013.

- **Option A: keep current regulatory framework as it is / no change**

There is no need to change the existing regulatory framework under Option A.

A detailed review of the various automotive radar technologies available today is necessary in order to assess the likely deployment of collision mitigation and avoidance applications under the existing regulatory framework and whether this is sufficient to stimulate further development of 79 GHz UWB SRR systems.

- **Option B: SRR systems in the frequency band 24-29 GHz (26 GHz UWB SRR)**

Option B consists of allowing the operation of SRR systems in the frequency band 24-29 GHz (26 GHz UWB SRR) in addition to frequency band 77-81 GHz (79 GHz UWB SRR) already designated in Decision ECC/DEC/(04)03. This will require a change in the current regulatory framework.

As indicated in CEPT Report 36, while the semiconductor technology for 79 GHz UWB SRR sensors is available now, the open issue of qualified sensors and their integration into cars, and validation of the vehicle application leads to a risk of an "availability gap" by 2013; hence the proposal for a shift to the 24-29 GHz band to bridge this perceived gap. Permitting 26 GHz UWB SRR sensors would allow car manufacturers which have already integrated 24 GHz UWB SRR sensors in some vehicle product lines to maintain safety applications based on the same sensor technology.

The request from ETSI for spectrum designation is documented in ETSI TR 102 664 which is presently under revision to reflect latest studies and development.

- **Option C: 24 GHz narrow-band radar systems (NB-24GHz) with extended band mode (WLAM)**

Option C consists of allowing the use of frequency band 24.25-24.50 GHz by 24 GHz NB radars in addition to the frequency band 24.05-24.25 GHz already designated in ERC/REC 70-03. This will require a change in the current regulatory framework.

Some equipment makers have proposed to improve 24 GHz narrow band radars by keeping the narrow band (24.05-24.25 GHz) and adding a wideband low activity mode, WLAM (24.05-24.50 GHz), which is only activated in specific driving conditions or in certain pre-crash conditions.

STAGE 4 – COLLECT DATA

This stage is essential for the quality of the report. Proper data on the market for collision mitigation and avoidance applications need to be collected, in particular from industry stakeholders.

Several information sources were already available when the discussions on the report were initiated:

- ETSI SRDoc on 26 GHz UWB SRR
- Request from Valeo/SMS for investigations on WLAM
- Results of EC Call for Input
- Contributions to RSC meetings …

More data needed to be collected in support of this assessment.

A) "Achieving the safety benefits of collision mitigation and avoidance application"

WGFM issued in May 2009 a **questionnaire** to consult more widely with industry stakeholders on this topic.

This report should provide an overview of the main driving assistance and safety applications that are or will likely be deployed based on radar technology (see **appendix 1**).

A better understanding of key drivers enabling the development of "collision mitigation applications" is also needed, knowing that affordable technology at low cost is usually seen as a precondition for technical implementation of SRR technology. It is also commonly understood that "safety applications" need to be packaged with driving assistance or comfort applications as consumer "do not buy safety" in the first place. The situation will evolve in time: while 79 GHz UWB SRR is not economically viable in the short term, it could be more readily viable if there are economies of scale and widespread consumer familiarity with radar based vehicle applications.

In general, the assessment should help providing a better understanding of the market situation:

- Main driver assistance and safety applications;
- Applications supported by different technologies;
- Industry stakeholders;
- Market shares/forecast for different technologies.

The safety features that can only be implemented with UWB SRR technology may need to be emphasized.

The underlying objective is to be able to explain how possible regulatory measures could help "*achieving the safety benefits of collision mitigation and avoidance applications*", or more generally to assess potential safety benefits resulting from the deployment of collision mitigation and avoidance applications under the identified scenarios.

B) "*Minimizing the costs associated with designating spectrum*"

There would be no adverse cost effect for other spectrum users under the assumption of compatible operation with radiocommunication services. Compatibility studies performed within SE24 have sought to identify possible technical measures to ensure coexistence with radio services without prejudging of the merits and justification for the identified regulatory options.

No data were therefore collected on potential costs for other spectrum users associated with the deployment of automotive radar applications.

STAGE 5 - DETERMINE THE IMPACT ON COMPETITION

No investigation on competitive issues has yet been conducted within FM47. Views on the potential impact of options A, B and C on competition of the different regulatory options may be reported in this section.

Bosch has also commented on spectrum availability and said that this and the regulatory provisions should be given for a reliable timeframe. Intermediate adaptation to bridge temporary delays in the introduction of applications or technologies should be handled very carefully and have to take into account the effort already spent by some manufacturers. Otherwise it would lead to a distortion of normal trading conditions due to creation of a quite new market in opposite to the Decision taken by EC in 2004. Missing credibility in EC decisions will influence strategic planning of investments of the industry in the future. Renault, TRW and PSA are in line with the Bosch comments. The 79 GHz frequency band itself will provide a competitive environment for SRR systems with different technological choices followed by stakeholders and will be amplified with a 79 GHz UWB worldwide harmonisation that is expected by all. Moreover, endeavours in technology particularly for packaging and function integration will open the industrialisation business to new comers allowing strong competition and cost reduction.

Germany and Italy, as well as some industry associations and individual manufacturers are of the opinion that a possible new enhanced regulation on automotive SRR should take into account the gained experience based on ECC decision ECC/DEC/(04)10 and Commission decision 2005/50/EC. In this regard a technology neutral approach that enables more than one solution, subject to proven spectrum compatibility, is a healthy way forward consistent to the general European policy that calls for technical innovation and market competition. Only competition between technologies, including competition to 79 GHz, will best achieve automotive safety goals. The automotive industry is not monolithic and several sensor technologies for object detection are on the market, including ultrasonic, radar (narrowband and UWB SRR, long range radar and possibly WLAM), lidar and optical applications. The use of 26 GHz UWB SRR would open the market for all UWB SRR applications and, in any event, protecting 79 GHz from competition is inconsistent with the EU regulatory framework.

STAGE 6 - ASSESS THE IMPACTS AND CHOOSE THE BEST OPTION

The basic question to be addressed and illuminated in this study should in theory be which regulatory action, including that of doing nothing, is best taking into account the costs and benefits and the policy objectives of improving road safety and securing optimal use of the spectrum. This would ideally involve an assessment of the costs and benefits. However, it might not be possible precisely to quantify all of these and estimates might be subject to a wide range of uncertainty.

This assessment focuses solely on assessing the road safety benefits that could be anticipated under different regulatory options. Some quantitive data on the safety benefit of automotive radar (see section 1.3), using a combination of UWB SRR and LRR radars, was presented, but it was not envisaged to compare the quantitative effect of the three options A, B and C due to the lack of comprehensive data e.g. on anticipated reduction in road casualties for each identified safety applications, the overall complexity of the model (performances of applications which may vary according to car classes, impact pending the occurrence of the type of accidents, timing issues in the automotive industry…) and high uncertainties on future technology market penetration under each option. Instead, an attempt is made to describe in a homogeneous manner the different collision mitigation and avoidance applications that are today already available or could be implemented in cars based on responses provided by industry stakeholders in response to a questionnaire issued by WGFM in May 2009 and more general review of market situation.

The other side of this assessment which would respond to the objective of “minimizing the costs associated with designating spectrum” has not been investigated within the frame of this Mandate as compatibility studies performed by SE24 have precisely sought to identify possible technical measures to ensure coexistence with radio services without prejudging of the merits and justification for the identified regulatory options.

In general, the assessment should help providing a better understanding of the market situation:

- Main driver assistance and safety applications;
- Applications supported by different technologies;
- Industry stakeholders;
- Market shares/forecast for different technologies (in low-end / medium-end/ high-end cars segments).

The following need however to be noticed when considering this analysis:

- For many items covered in this questionnaire little or no detailed information can be given because of confidentiality issues with respect to competition.
- There is no official definition of applications, leading to different understandings of the content of a specific application.
- According to car class or car line respectively performance requirements for each application can vary.

1 AUTOMOTIVE DRIVING ASSISTANCE AND SAFETY APPLICATIONS: OVERVIEW

1.1 Development and Production Cycles in the Automotive Industry

Some of the key constraints of car manufacturers are well described in CEPT Report 36 developed in response to Part 1 of the EC mandate on SRR, in particular the fact that the technology to be used in a car line must be fixed several years before start of production (SOP). A phase of car integration and extensive car tests will require several years in addition to the research and technology development phase in order to ensure that all safety aspects are correctly implemented. After product design, the release for series production in a car line is possible with modern production systems with a lead time of 2 to 4 years after sensors are available for car integration. During the production time of a car line a change of technology is very difficult.

SARA has provided in its response to the questionnaire on SRR the figure below that illustrate the typical product life cycle (about 15 years) of a car line:

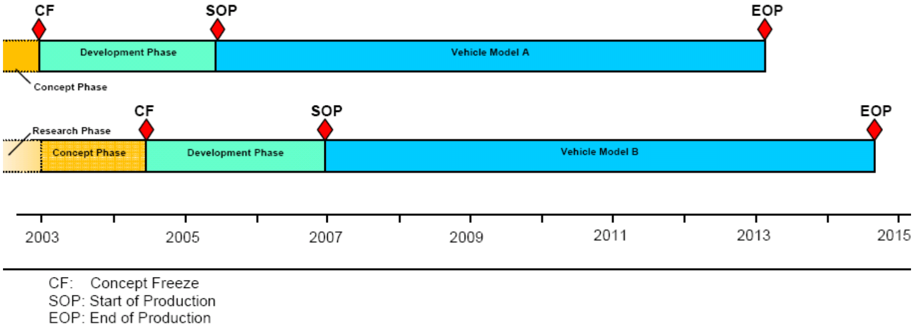

Figure 1: Development and Production Cycles in the Automotive Industry

ACEA has also underlined the research and development up to 7 years, production time 7 to 8 years, vehicle life time of about 15 years.

The progression of different development phases for automotive components using the example of 79 GHz UWB SRR is illustrated in the following Table 1, showing process steps achieved and planned.

Process Step	Description
Semiconductor technology	Semiconductor Development (Kokon Project 2004-2007)
Sensor	Sensor and component development (MMICs, ASICs) (RoCC Project 2008-2011) Development of a sensor for answering the specification of the ACC, the pre-crash and the collision mitigation with the 76 GHz/79 GHz UWB technology. (RADAR ACC Project 2007-2010)
Car integration and application	Sensor suitable for mass production New materials for bumper / paintings (transparent at 79 GHz) Car integration and application development The issues regarding to the bumper, the paintings and the integration of the 79 GHz UWB sensor in the vehicle are studied in the ARPOD project 2009-2012.
Test under real world conditions	Test of sensor and application (up to 1 Million driven km for safety related functions)

Table 1: Process Steps in the Sensor System Development

1.2 Automotive applications: from driving assistance to more safety features

A description of the main driving assistance and safety applications that are already or likely will be deployed based on radar technology is given in **appendix 1**.

Driving assistance and/or comfort applications at prices the market will support are essential for the automotive industry as consumers “do not buy safety” in the first place.

ACC is a key-radar feature which was introduced in 1998 and is increasingly being completed with Stop and Go functionality. Parking assistance is becoming very popular as well. Radar technology can be used but is not critical for this type of application.

Early implementation of warning safety features first concentrated on the front side of the vehicle with Forward Collision Warning (FCW) and Collision Mitigation, followed by rear or side applications with Blind Spot Detection (BSD), Cross Traffic Alert (CTA) and Lane Change Assist (LCA). For Forward Collision Warning (FCW) and Collision Mitigation there is a higher requirement for range and distance resolution. In sum, automotive radars allow both active and passive safety applications, leading to concepts of “integrated safety”.

Beyond Collision Warning, enhanced safety features can be implemented, ranging from pre-crash passive safety measures to emergency braking or brake assist.

Different equipment suppliers and vehicle manufacturers will choose different strategies. For instance, Bosch has indicated that basic warning features (e.g. early detection of impeding rear-end collisions) are planned as a bundle with activation of seat belts and other actuators (passive safety).

Radar based pedestrian protection, which appears as the most recent safety functionality has been implemented by Daimler with BAS PLUS (Brake Assist system). This safety feature will also be implemented in 2010 on new Volvo S60.

1.3 About safety benefits

Various studies on the safety benefit of automotive safety systems have been published, especially at the recent 21st International Technical Conference on the Enhanced Safety of Vehicles, Stuttgart, held in June 2009:

- *Daimler*[10] stated that with its Brake Assist Plus (collision warning and partial braking) it is possible to prevent 53 % of all rear-end collisions that otherwise cause injuries. To support this figure, a comparison of repair parts statistics of cars with and without radar - based functions was made. It could clearly be shown that impacts at speed between 14 and 50 km/h could be reduced by 22%. It could also be shown that the impact speed at collisions was reduced (e.g. impact speed between 14 and 45 km/h by 38%). In sum crashes could be avoided or at least the impact speed be reduced significantly.
- The *Swedish Road Administration* (SRA)[11] published a study that reduction of collision impact speed by 10% would reduce risk of fatalities by 30%.
- *German Insurers Accident Research* (UDV)[12] stated that autonomous partial braking could avoid 12% of all accidents. Systems with autonomous emergency (full) braking could avoid 40% of all kind of collisions.

SEISS - study

In FP6 the SEiSS study (Exploratory Study on the potential socio-economic impact of the introduction of Intelligent Safety Systems in Road Vehicles, 2005) developed a methodology for assessment of the socio-economic benefit of vehicle applications. As an example a calculation was made for Adaptive Cruise Control ACC (77 GHz Long Range Radar only, SRR was not available at that point in time):

> *The monetary assessment of ACC safety impacts leads to considerable **benefits**. They account for 490 million € in the year 2010. In 2020, the attainable benefits total 990 million €. The following figure shows the distribution of the safety benefits among different components. More than 40% of the total benefits can be attributed to the reduction of fatalities, with a similar contribution being made by the reduction of severe injuries. The remaining 20% of benefits are distributed among the reductions in slight injuries (10%), in property damages (5%) and in congestion (5%).*

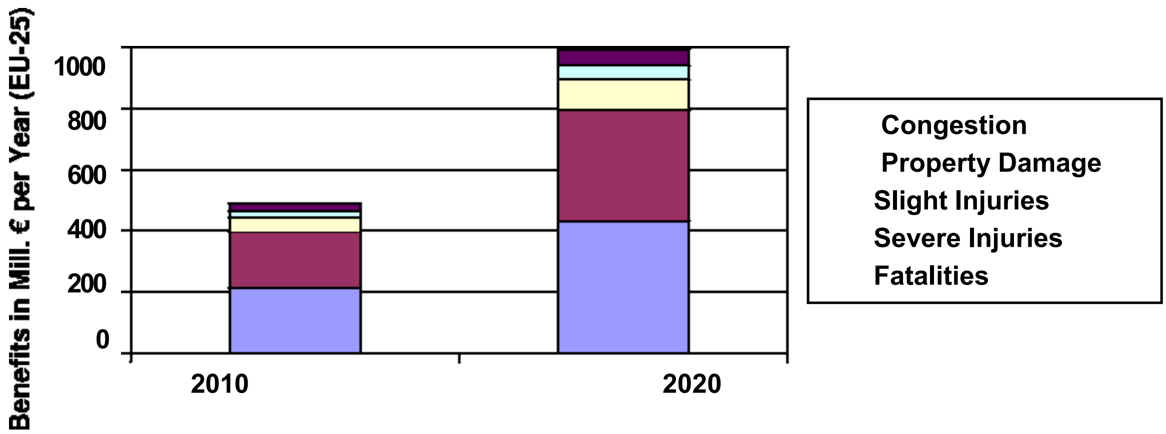

Figure 2: Socio-Economic Benefits of ACC (EU-25; author´s calculation)

The socio-economic benefit of ACC was assessed to be significant. Today’s systems like emergency braking (ACC-radar in combination with UWB SRR) will have even higher impact.

The study can be found at http://www.eimpact.info/download/Final_SEiSS.pdf.

Considerations on action taken by the authorities in favour of road safety

The action taken by the authorities in favour of road safety actually concerns the three elements in an accident: the road user and the driver in particular – the road and its environment – the vehicle – as well as their interactions. All these actions

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10 Helmut Schittenhelm, The Vision of Accident Free Driving – How efficient are we actually in avoiding or mitigating longitudinal real world accidents., 21st International Technical Conference on the Enhanced Safety of Vehicles, Stuttgart,2009

11 Claes Tingvall et al., The Effects of Automatic Emergency Braking on fatal and serious Injuries, 21st International Technical Conference on the Enhanced Safety of Vehicles, Stuttgart, 2009

12 Matthias Kuehn et al., Benefit of Advanced Driver Assistance Systems for cars derived from real-life accidents. 21st International Technical Conference on the Enhanced Safety of Vehicles, Stuttgart, 2009, and http://www.udv.de/fahrzeugsicherheit/aktuelles/artikel/auffahrwarn-und-notbremssysteme-haben-hohes-unfallvermeidungspotential/

are made more effective through the development of a better knowledge of the accident and a strong local policy aimed at involving local government representatives.

In addition the European Commission launched its eSafety program with the goal to reduce fatalities by 50% until 2010. The industry reacted to develop many applications based on detection of objects, which are on the road today. Manufacturers use UWB SRR operating at 24 GHz as well as (partially) long range radar at 77 GHz (in front and rear) or (also partially) Narrow Band SRR at 24 GHz ISM-Band. In the future 79 GHz UWB SRR will be used as the next generation of UWB SRR. In parallel to radar also other technologies such as cameras and lidar are in use.

Potential safety benefits associated with the implementation of driving assistance and safety applications rely on numerous factors. One of these factors is obviously the occurence of the type of accident that is addressed by a certain application. The 2007 report on Road Safety in France from the National interministerial road safety Observatory (ONISR[13]) provides for instance useful indication about accident conditions in France (2007): 20.6% of accidents concern one vehicle only without a pedestrian involved, 16.0% one vehicle only with a pedestrian involved. 11.1% collisions are head-on collisions.

The figures below from the 2008 report provide a more complete picture of the situation, distinguishing the accidents involving one vehicle only (with or without a pedestrian), two vehicles (frontal, lateral, rear collision or other), three or more vehicles (chain collisions, multiple collisions or other).

Accident conditions in France (2008)	**Road accident injuries**		**Road accident fatalities**	
	Number	**%**	**Number**	**%**
One vehicle only with pedestrian(s)	12 791	16,7	541	12,2
One vehicle only without pedestrian	15 888	20,7	1 630	36,7
Total accidents with one vehicle only	28 679	37,4	2 171	48,9
Two vehicles :				
- frontal collision	7 567	9,9	1 005	22,6
- lateral collision	23 199	30,2	646	14,5
- rear collision	8 358	10,9	209	4,7
- other collisions	4 067	5,3	76	1,7
Total accidents with two vehicles	43 191	56,3	1 936	43,6
Three vehicles and more :				
- chain collision	2 114	2,8	51	1,1
- multiple collisions	2 386	3,1	269	6,1
- other collisions	397	0,5	16	0,4
Total accidents with three vehicles and more	4 897	6,4	336	7,6
Total	76 767	100,0	4 443	100,0

Table 2: road accident injuries and road accident fatalities versus accident conditions (Source ONISR)

Statistics studies of direction of impacts on a vehicle from the institute GIDAS (German In-Depth Accident Study) – and NHTSA (National Highway Traffic Safety Administration) show that accidents on the lateral parts and rear parts of a vehicle are also important in comparison with the front of a vehicle. The global safety includes radar applications indicated in Appendix 1 of this report and the passive safety (seat belt pretension and airbags pre-firing for frontal and side/rear impact and whiplash prevention for side/rear impact).

[13] Observatoire national interministériel de sécurité routière, see http://www2.securiteroutiere.gouv.fr/infos-ref/observatoire/observatory.html

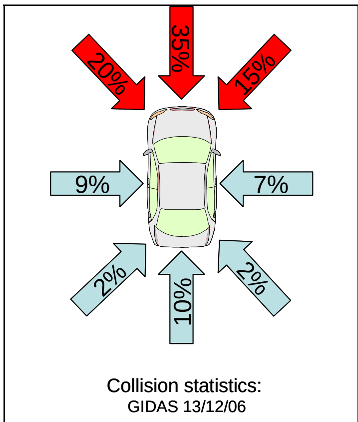


Figure 3: Collisions statistics of frontal safety (70%).

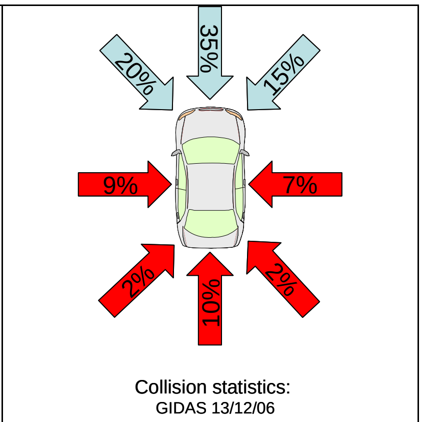


Figure 4: Collisions statistics of rear and side safety (30%).

1.4 Market trends

As indicated by SARA in its response to the questionnaire on SRR, macro trends are influencing the automotive industry. Rising energy costs require fuel efficiency. This results in a shift towards smaller and lighter vehicles. But there is also an increased demand for vehicle safety. Both trends create a growing need for active safety systems to avoid or mitigate the severity of crashes. Thus, the automotive industry has strong incentive to develop the most efficient and effective approach towards new safety applications.
At the same time, the economic situation of the automotive industry is under pressure. Suppliers and vehicle manufacturers must maximize available synergies and improve development efficiency. Versatile radar sensing platforms, including multi-mode sensors are required, which enable vehicle manufacturers to launch many applications using a common radar platform.

According to SARA, nearly every vehicle manufacturer has launched or is in the process of launching applications that use radar sensor technology. The question is no longer “if” but rather “how” the market will evolve. Focus has shifted to reducing cost in order to improve the take rate of such options and make the systems available to more consumers on affordable low priced, high volume vehicle lines. (High volume vehicle lines are important to achieve a high benefit for road safety.) Marketing studies show a direct relationship between feature price and consumer interest. The industry development efforts are rapidly shifting towards active safety applications which require robust sensor solutions (more data, better data, more quickly). Low cost nevertheless remains a mandate, increasing the challenge to suppliers.

Daimler has said that the amount of cars equipped with radar based technologies could grow enormously because manufacturers are planning to integrate radar systems not only in high end car lines but also in mid and low end car lines. For example, Daimler introduced UWB SRR (24 GHz) in 2005 as the first car maker worldwide and wants to bring the active and passive driving assistance systems in all its platforms including small cars up to 2013 and beyond. Quite recently its new E-class with these systems was introduced.

PSA also foresees market growth with some market analysis indicating that the number of Short Range Radars installed in vehicles will have the potential to grow to 50% during the next 3 years.

In general, the responses provided in the questionnaire suggest a potential for significant growth of driving assistance and safety applications in the coming years. It is visible from production data that the take-up rate is remarkably high for car lines where radar-based safety options are offered by the manufacturers compared to take-rates for ACC comfort applications (based on 77 GHz long range radar) even though ACC has been on the market since 1998.

Even in data fusion solutions, radar is estimated to be the most important basis sensor technology for safety applications. Other sensor elements like cameras etc. are used as complements to radar technology.

2 RADAR TECHNOLOGIES

2.1 Terminology

The following terminologies and acronyms are proposed to be used when comparing different categories of automotive radar systems:

- 24 GHz UWB SRR: automotive radar systems operating in the frequency band 21.65-26.65 GHz
- 26 GHz UWB SRR: automotive radar systems operating in the frequency band 24-29 GHz
- 79 GHz UWB SRR: automotive radar systems operating in the frequency band 77-81 GHz
- 24 GHz NB radar: automotive (narrow-band) radar systems operating in the frequency band 24.05-24.25 GHz (also referred as NB-24GHz)
- 24 GHz NB/WLAM radar: automotive (narrow-band) radar systems (NB-24GHz) with extended band mode (also referred as NB-24GHz/WLAM)
- 77 GHz radar: automotive radar systems in the frequency band 76-77 GHz.

Radar technology is designed to fulfil the requirements of the envisaged vehicle application; the sensor requirements may be different for different vehicle applications.

Appendix 2 of this assessment report (applications table) indicates for various equipment makers and vehicle manufacturers the technology (or combination of technologies) that is used or planned to be used to provide relevant safety or driving assistance application. This information is based on the responses to the questionnaire issued by WGFM in May 2009.

The answers to the questionnaire show the various sensing strategies implemented by the European vehicle manufacturers:

- Many have reported available sensing technologies which are in accordance with long-term European regulation (77 GHz & NB-24GHz radars implementation in progress),
- Some of these vehicle manufacturers have also mentioned 79 GHz UWB SRR for emergency braking,
- 24/26 GHz UWB SRR for emergency braking has been reported by Daimler and some US car-makers in combination with other technology (77 GHz radar or vision systems).

(Source VALEO)

2.2 Key drivers

Affordable and reliable safety technology: Vehicle manufacturers are expected initially to consider radar-based solutions which are affordable (key driver for this is volume) and provides robust sensing when operating in a variety of environmental conditions, (e.g. rain, snow, fog, etc). Harmonization of the radar frequency bands for automotive applications worldwide would greatly increase the volumes of the radar units, which would reduce the cost significantly and enable the manufacturers to put safety applications in more cars more quickly.

SARA has emphasized in its response that the range resolution is the ability of a radar system to distinguish between two or more targets on the same bearing but different ranges:

- High resolution is required to reliably analyse the complex car environment and to distinguish between different objects which are close together.
- Precise object trajectory calculation and object location is needed for prediction of further object movement and correct interpretation of the road scenario.
- Low resolution will result in unreliable forecasts and false alarms.
- Low resolution systems will miss small objects in front of a big one.

For VALEO, pre-requisites for the use of radar-based solutions are a

- Worldwide frequency approval perspective to support 2012/13 SOPs

- Low interference risk with existing services
- Capable of automatic braking for cars and trucks (legal requirement 2013 for trucks)
- Capable of driving assistance features the end-users will buy
- Capable of multiple features and ranges for vehicle manufacturers to get a standard technology
- Solid business case and concrete volume & cost reduction perspectives
- Consistent with radar technologies already planned by EU car-makers for 2012/13 SOPs

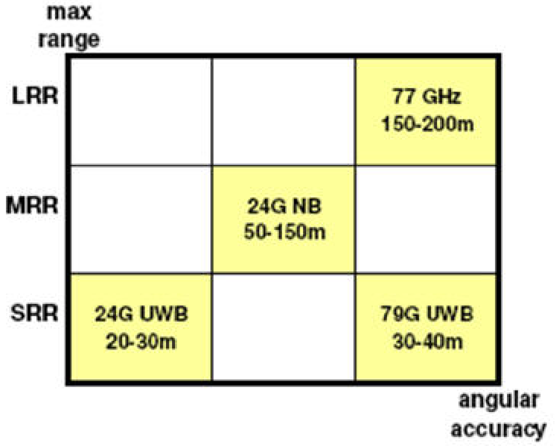


Figure 5: Different Radar Technologies – measurement range and angular accuracy (Source VALEO-SMS)
(NB: Bosch states that 79 GHz UWB can also be used as MRR)

In contrast to the above figure from VALEO, other companies provided the following figure that gives an overview over the key parameters as Doppler (relative speed) resolution, the angle resolution and range or object discrimination resolution (Source ETSI TR 102 664 V1.1.1).

The picture shows that SRRs operating at the highest frequency and with high bandwidth provides the best SRR performance.

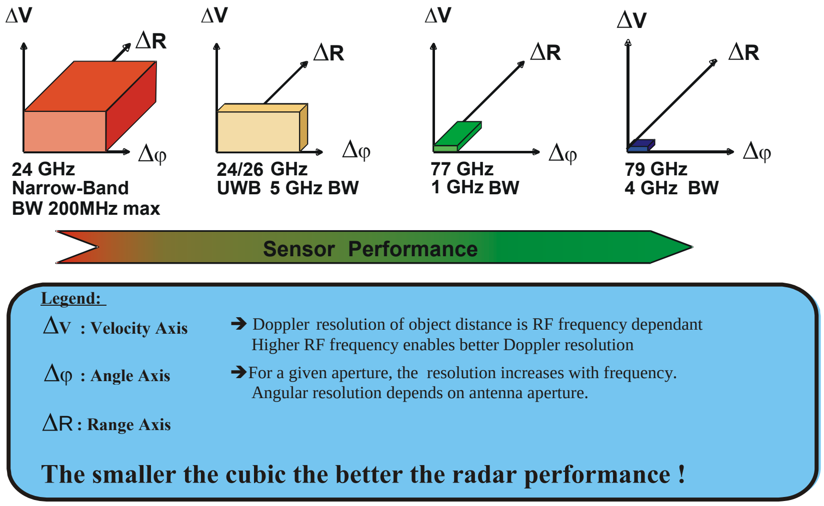


Figure 6: Sensor performance showing the key parameters local resolution, angular resolution, Doppler speed information

Bosch underlined in its response that a full-scaled vehicular safety system requires short or mid & long range radar sensors.

Consideration on UWB SRR technology

UWB technology allows a high resolution due to high bandwidth. This enables it to analyze complex traffic situations e.g. small objects close to vehicles, to interpret the dangerousness of a traffic situation. High resolution is a key to enable precise object detection.

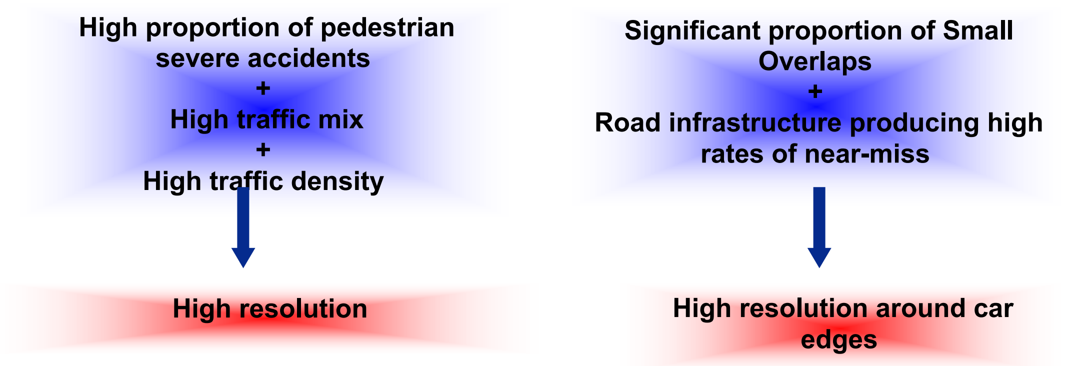
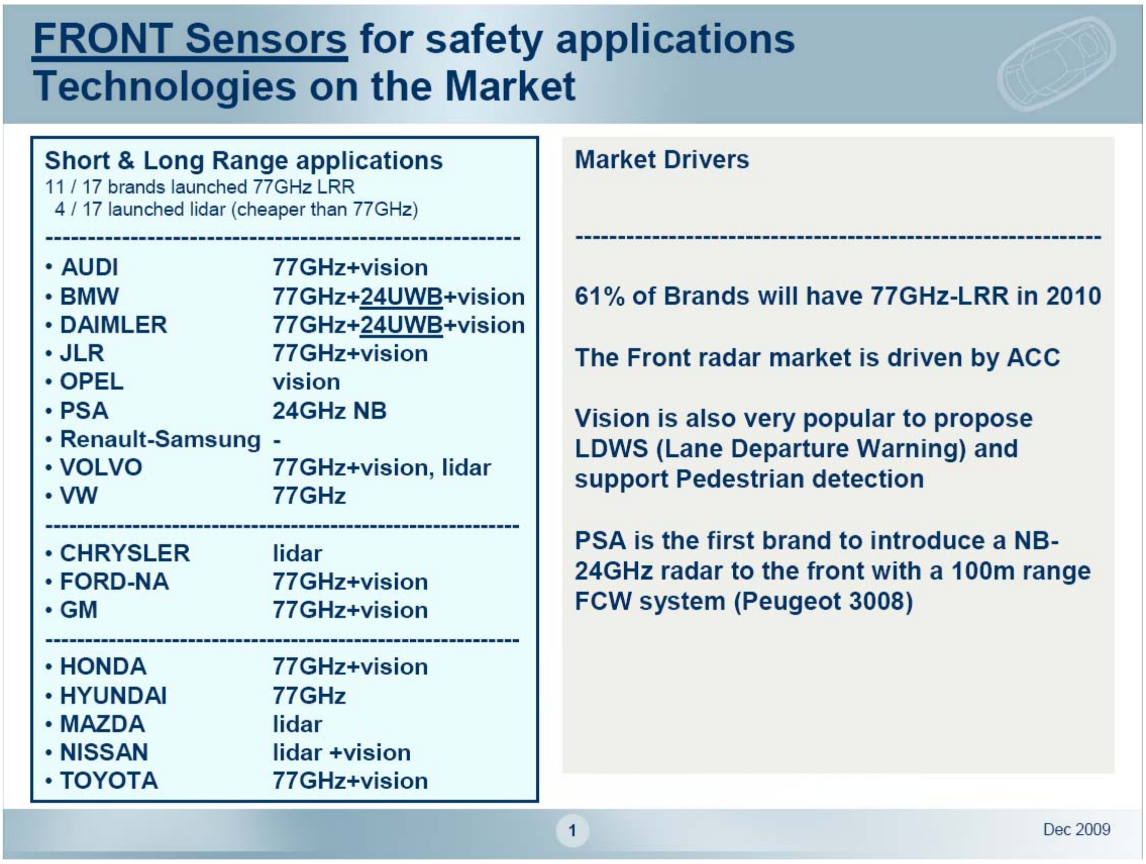


Figure 7: High resolution is essential for real world scenarios (Source SARA)

2.3 Market shares

The following figures have been submitted by Valeo to the RSC meeting in December 2008 and have been updated following discussions within CEPT. They give an indication of the main industry stakeholders by distinguishing front and rear radars:



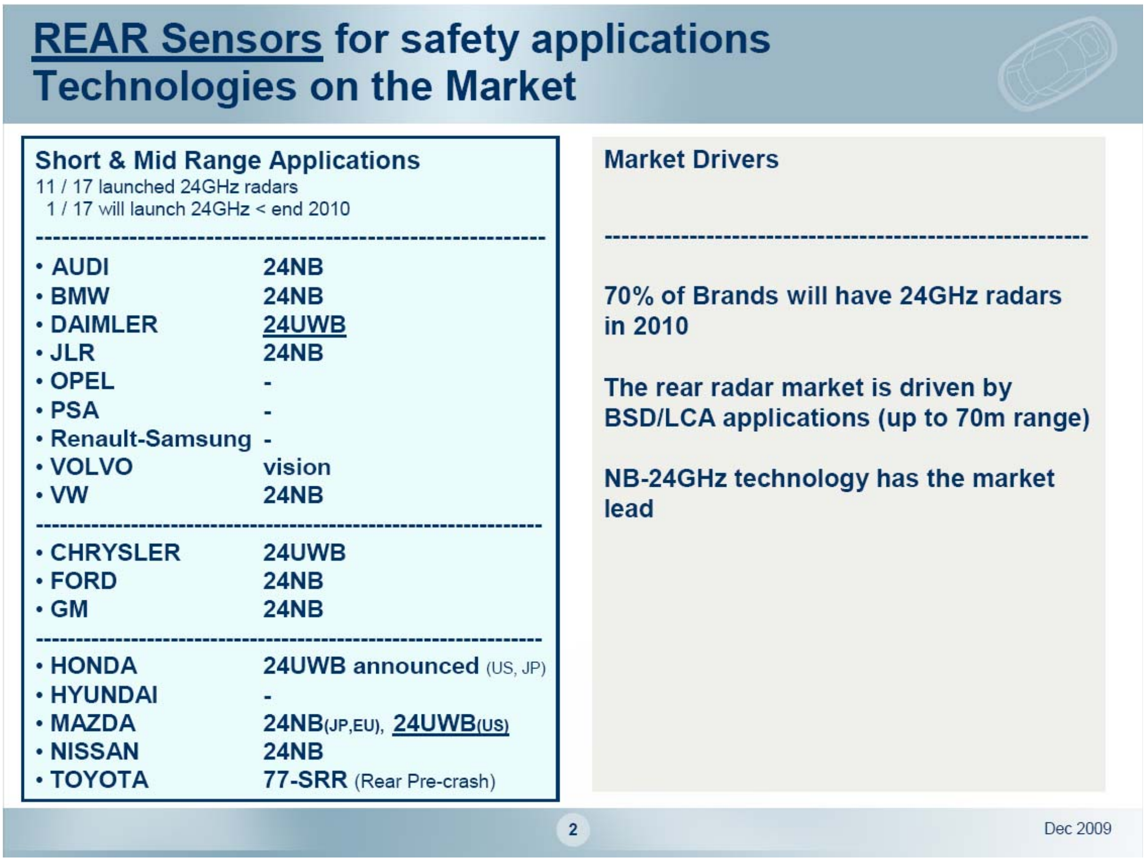


Figure 8: technologies on the market

For front applications, three technologies (NB SRR and NB MRR, UWB SRR, LRR-ACC) can be used. For ACC applications NB-24 GHz radars compete with 77 GHz radars (which have a somewhat longer range). Estimates from VALEO are that ACC radars will be split in 2 technologies in 2017, likely with an equal market share:

- LRR 77 GHz (premium segment) 2,5 million units
- NB-24GHz front MRR (medium segment) 2,5 million units

Strategic Analytics 2008 market survey realized before the crisis, mentioned 5Mu ACC radars already in 2015.

NB-24GHz radars related to rear applications which are already launched by many customers are estimated to:

- NB-24GHz rear radars 6.5 million units

(Source VALEO)

SARA expressed that those NB figures are very high due to the time limit of 2013 in Europe for 24 GHz UWB SRR. In addition even the markets without time limitation suffer the effects of the European deadline. Flexible frequency designations for UWB SRR will shift the technology trend from NB to UWB SRR because of the increasing bandwidth requirements resulting from new generations of automotive safety related applications.

The SRR market especially in North America is developing and UWB SRR has been implemented in cars of several manufacturers, commercial trucks and even in school buses. Applications cover all sides of the car from Forward Collision Warning and Emergency Braking up to observation of objects at the vehicle side and rear. As rough market estimation more than 1 million units (by end of 2008) can be assumed based on sales figures from several manufacturers.

Finally, this information about radar technologies currently integrated in road vehicles needs to be completed by an indication of market share of the main vehicle manufacturers in Europe as given below. It cannot be assumed that the entire product line of each manufacturer is or will be equipped with the radar technology noted:

	January – December 2009		Basis radar technology	
BRANDS	**%Share**	**Units**	**Front sensors**	**Rear sensors**
VW Group	21.1	3 064 748	77GHz	24NB
PSA Group	13.0	1 885 788	24NB	-
FORD Group	10.4	1 503 290	77GHz	24NB
RENAULT Group	9.3	1 348 256	-	-
GM Group	8.8	1 282 854	77GHz	24NB
FIAT Group	8.6	1 254 952	-	-
TOYOTA Group	5.0	730 536	77GHz	77GHz
BMW Group	4.9	708 357	24UWB + 77GHz	24NB
DAIMLER	4.7	684 113	24UWB + 77GHz	24UWB
NISSAN	2.5	368 478	-	24NB
HYUNDAI	2.4	346 028	77GHz	-
SUZUKI	1.7	249 789	-	-
HONDA	1.7	244 325	77GHz	24UWB
KIA	1.8	256 926	-	-
MAZDA	1.5	210 711	-	24NB (JP, EU) + 24UWB (US)
MITSUBISHI	0.7	97 267	-	-
JAGUAR LAND ROVER Group	0.6	85 868	77GHz	24NB
CHRYSLER Group	0.4	54 628	-	24UWB
OTHER	1.0	125 170	-	-
ALL BRANDS	100,0	14 524 084		

Table 3: New passenger car registrations by manufacturer - total EU + EFTA countries and technology choice (Source ACEA)

With the understanding of key constraints of the automotive industry in development and production cycles recalled in section 1.1, today's picture of technologies on the market is essential to understand the trend for greater deployment of radar technologies in road vehicles towards increased road safety.

2.4 24 GHz and 26 GHz UWB SRR

2.4.1 Industry stakeholders

Autoliv and Continental are known equipment makers offering 24 GHz UWB SRR systems.

In 2008 Autoliv acquired the radar business from Tyco Electronics M/A-COM. Continental acquired in 2007 the automotive business of Siemens, including the 24 GHz UWB product line and SRR know-how.

Daimler introduced UWB SRR in 2005 based on the European regulatory package to make safety benefits available as early as possible. Daimler appears as the leader among vehicle manufacturers worldwide for the implementation of this technology and offers today a wide range of driving assistance and safety applications.

SARA has observed that other car makers offer a subset of these applications and are working on a wider range of these applications. These companies include BMW, Chrysler together with Fiat, General Motors together with Opel, Ford, Honda, Mazda, Toyota and Volvo-Trucks. Numerous companies in the supply chain are involved, including system suppliers and their sub suppliers.

The figure below provides an overview of the suppliers which have made substantial investments on 24 GHz / 26 GHz UWB technology.

Company	Tier One	Tier Two	Tier Three
Autoliv	X	X	
Continental	X	X	
Furukawa		X	
Analog Devices			X
Atmel			X
Hittite			X
IBM			X
Rogers			X
ST Microelectronics			X
Texas Instruments			X
UMS			X
Xylinx			X
Mitsubishi Electric			X
Infineon			X
Tier One: System integrator of applications			
Tier Two: Sensor supplier			
Tier Three: Component supplier			

Figure 9: Overview of suppliers working on the 24 GHz / 26 GHz UWB (Source SARA)

2.4.2 Key features and enabled applications

The need for UWB radar is derived from safety applications in complex road traffic scenarios, e.g. suburban and urban areas. UWB SRR systems provide a high object separation capability and distinguish between different objects, including the detection of small objects in the vicinity of large objects (e.g. passenger besides a vehicle or a motorcycle near a truck). This can only be achieved by a high resolution which requires a high bandwidth. The precise object tracking is important to decide if an object might collide with a vehicle. (Source SARA)

In combination with a 77 GHz long-range radar sensor the 24 GHz UWB short-range radar sensors provide an improved ACC functionality. The 77 GHz long range radar sensor covers the lanes in front of the vehicle for a distance of 150 … 250 m. The 24 GHz UWB sensors fill up this detection area in the near and mid range. This sensor fusion extends the operating speed to a range of ACC down to 0 km/h (Stop&Go) and allows applications not only on highways but also in dense and city traffic.

Sensor performance requirements and technical data may differ from application to application on the one hand side and for the same application from vehicle manufacturer to vehicle manufacturer.

Daimler offers a full range of driving assistance and safety applications and has provided its performance requirements for short and long range sensors in its reply to the questionnaire.

According to Autoliv and Continental, REAR applications using 24 GHz UWB SRR are successful:

- Blind Spot Detection (10 m warning), in production
- Cross Traffic Alert (25 m warning), in production
- Lane Change Assist (50 m warning)
- Rear Pre-Crash (30 m range)
- Back-up aid (15 m range), in production
- Parking aid, in production

As well as FRONT applications:

- ACC stop & go*, in production (since 2005)
- Forward Collision warning and partial braking* in production (since 2005),
- Autonomous emergency braking*, in production (since 2009)
- Front pre-crash, in production (since 2005)

* In combination with long range sensors.

2.4.3 Availability

24 GHz UWB radars have been in production since 2005. Since then new car lines have been launched that include front, rear and side applications. SARA says that 24/26 GHz can address most of today's safety and comfort applications and that the 24 GHz technology has a clear cost reduction road-map to make 24/26 GHz sensors based applications more affordable to the customer. After the first introduction of this new technology in higher class cars (it is a normal procedure to introduce new technology in higher class cars first), now the steps from higher class to the middle and lower class volume car lines can be continued. Also, the extremely cost sensitive truck segment now uses 24 GHz UWB SRR.

24 GHz UWB SRR are available and are promoted as proven technology for various automotive driving assistance and safety applications. However in Europe the installation of 24 GHz UWB SRR sensors in new cars will not be allowed after 2013.

26 GHz UWB SRR would be readily available as a replacement for 24 GHz UWB SRR at the cut off date. Indeed the shift to the 26 GHz band would be reasonably easy to achieve. SARA argues that without 26 GHz the UWB SRR technology will drop in the automotive market due to the UWB gap.

However, noting the evolution path between 77 GHz sensors (on the road since 1998) and 79 GHz, some administrations have are doubts about this gap, how long it is expected to last and for how long the proponents of the 26 GHz solution expect this band to be made available. The success of 79 GHz UWB SRR will depend on the maturity of the market for road safety and driving assistance applications and on consistency with initial regulatory decision to allow cost effective and competitive sensors.

SARA has stated that 79 GHz sensors do not meet the SOP (Start of Production) requirements of some car manufacturers for car lines crossing the 24 GHz UWB deadline of 2013. German research programs started in 2005 (Kokon 2005-2007) and will last until 2011 (RoCC 2008 - 2011).The vehicle integration has to be solved due to the higher operating frequency. Additionally investigation on bumper materials and paints are necessary for 79 GHz, followed by extensive in-vehicle tests. For 26 GHz these problems are solved already.

SARA maintains that 26 GHz UWB is necessary to develop the market for UWB SRR applications. Otherwise other countries such as the US and Japan – which permit this technology -- will take away the current technology lead from Europe. (Source Autoliv)

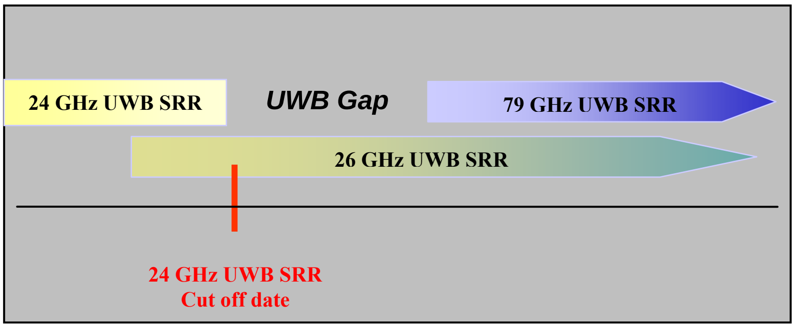


Figure 10: Future development and UWB gap as seen by SARA

For some administrations, the time limitation of the existing European regulation for the 24 GHz UWB SRR does not seem sufficient to explain the low penetration figures of this technology (less than 0.1% in Europe in 2009). Manufacturers have underlined that the coupling of 24 or 26 GHz UWB SRR sensors with 77 GHz radar sensors yields significant integration problems and induce high costs. While this approach may be viable for premium cars, it is not likely to allow equipping the whole range of vehicles. The concern that allowing 26 GHz UWB SRR will fragment the market for UWB sensors and thus risk jeopardizing long term efforts to bring down the costs of UWB sensors at 79 GHz has also been expressed.

As for the risk of market fragmentation, PSA expressed that in the hypothesis enabling the 26 GHz UWB technology, the cost of 79 GHz UWB technology risks to increase significantly with regard to the cost planned at present time. These additional costs, not insignificant for volume car manufacturers, will not permit to equip massively the whole range of vehicle including the low cost ranges which become more and more widespread. (Source: PSA)

SARA thinks however that this view cannot be generalized. It is not shared by some car makers: Some manufacturers use a set of sensors, each dedicated to a special vehicle application. They use a combination of Long Range Radar (LRR) with SRR to have enhanced detection reliability because of the two independent sensor systems. The combination of LRR (77GHz) and SRR (24 GHz) is a preferred way to keep cost low (24 GHz technology is widely used in consumer products) and to make applications affordable for the customer. Especially one vehicle manufacturer with a long experience in radar based applications has the strategy also to equip his car lines of small and low cost cars also with this combination. In addition, the 26 GHz approach would keep UWB SRR in the cars. Today's applications follow the demand of the customer and develop the market for UWB SRR, including 79 GHz SRR.

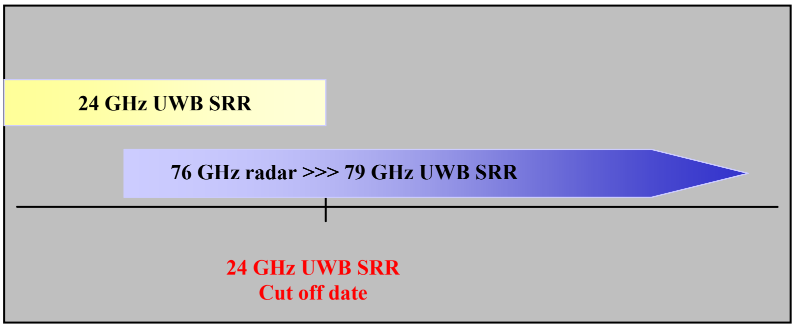


Figure 11: Future development as seen by some car manufacturers (79 GHz UWB SRR as a continuation of 76 GHz radar technology)

2.4.4 Worldwide regulatory environment

FCC Part 15 regulation provides technical requirements for vehicular radar systems (§ 15.515) operating in the US within the frequency band 22-29 GHz. A vertical attenuation of 25 dB from 1.1.2005 and 30dB from 1.1.2010 applies to emissions within the frequency band 23.6-24 GHz.

From 1.1.2014, this level of attenuation for the US market shall be 35 dB for any emissions within the 23.6–24.0 GHz band that appear 30 degrees or greater above the horizontal plane. This latter restriction is of particular importance and provides an incentive for the industry stakeholders who implement this technology to migrate from 2014 to 26 GHz UWB SRR operating within the frequency band 24–29 GHz.

General Motors underlined in its response to the questionnaire on SRR that a permanent 24-29 GHz UWB band in Europe would overlap with the permanent 22-29 GHz UWB band in the US and expected (by 2010) 22/24-29 GHz UWB band in Japan. (Source: GM)

UWB SRR Regulations were adopted in Japan to be effective in April 2010 with the following constraints:

- 24 GHz UWB SRR is allowed until 2016. Stations already in use at that date can continue.
- 26 GHz UWB SRR is allowed with no time or penetration limit

Today 24 GHz UWB SRR is sold in most of the main markets (nearly 60 countries).

2.5 24 GHz NB radar

2.5.1 Industry stakeholders

VALEO, HELLA/SMS, Autoliv, Continental and TRW are known equipment makers offering NB-24GHz systems.

2.5.2 Key features and enabled applications

According to VALEO and SMS, REAR applications using NB-24GHz are successful:

- Blind Spot Detection (10m warning) in production
- Cross Traffic Alert (25m warning) in production

- Lane Change Assist (70m warning) in production
- Rear Pre-Crash (60m range) in production

And FRONT applications are coming in the 2009-2013 time-frame:

- Forward Collision warning (100m+) in production
- Front pre-crash & automatic braking
- Low-cost ACC zero speed up to 130km/h

The NB-24GHz 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 very popular on the automotive market since they can realize most of the *driving assistance* features (range up to 150m) at a competitive cost. This should be balanced in case of ACC as the medium range offered by NB-24GHz would not be suited for any kind of highway scenario, as underlined by Bosch.

For SARA, narrow band radars (typical bandwidth 100 MHz) are limited in applications because of their limited local resolution and therefore limited capability of object separation or of object tracking (discussed further below). Today, narrowband applications on the road are constrained to a reduced set of *safety* functions such as Blind Spot Detection (objects in the blind spot of the mirror) and Lane Change Assistance. (Source SARA)

Autoliv also expressed that there are classes of real world scenarios that simply cannot be addressed by 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 (or less) that NB resolution, thus the NB radar would be unable to resolve the pedestrian. (Source Autoliv)

2.5.3 Availability

NB-24GHz radars are already in production for front (PSA) & rear applications (BMW, VW, AUDI, JLR, MAZDA, FORD, GM), with a solid business case since they can address also the mid-range applications that end-user will buy and since the 24GHz technology has a clear cost reduction road-map. This makes this technology attractive to the vehicle manufacturers, especially since new developments and prototypes have shown a high capability to include safety features with a good performance.

VALEO underlined that the limitations specific to a 200MHz bandwidth which can be noticed in critical environment – like parking for pedestrian detections – can be solved by a small increase of the bandwidth and a low activity factor which will minimize the interference risk with existing services (Option C - WLAM concept). The 30cm resolution of the 450MHz WLAM mode will be similar to the resolution of Toyota 77GHz ACC and pre-crash systems (bandwidth <500MHz in Japan), and the combination of WLAM sensors with ultrasonic sensors (a standard and cheap technology) will allow a premium resolution in the very short range, and will be useful for pedestrian detection in city and parking conditions.

24GHz NB Radars are already a successful market with the current GaAs technology and market growth will be stronger once the cheaper SiGe technology is introduced around 2013 time frame. (Source VALEO)

The success of 24 GHz NB radars can be first explained by its availability allowing gradual implementation of some driving assistance and road safety applications in cars. Some suppliers have announced ACC Stop&Go with pre-crash applications in production by 2013. These radar based systems would fit the proposed EU regulation to mandate automatic emergency braking systems for medium and heavy commercial vehicles in 2013.

2.5.4 Worldwide regulatory environment

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

2.6 77 GHz radar

2.6.1 Industry stakeholders

Bosch, Continental, Hitachi, Delphi, Fujitsu-Ten, Denso and TRW are known as equipment makers offering 77 GHz radar systems.

2.6.2 Key features and enabled applications

For long range radar applications (LRR), 77 GHz sensors are state-of-the art: Adaptive Cruise Control (ACC) using this technology experienced a steady growth during the last decade (market introduction 1998).

1st and 2nd generation ACC systems disabled themselves at speeds below 30 km/h and this "Non Stop&Go" was reported to be the weak point of 77 GHz radars (Auto-Motor Sport – July 08, quoted by Valeo). There was a substantial increase in sales volumes once "ACC stop & go" was introduced in 2005, based on a combination of 77 GHz radar and 24 GHz UWB SRR. This application allows (a) the car to be stopped completely and (b) allows for automatic following another car.

The automatic partial brake (in 2005) and emergency braking function (in 2009) introduced by Daimler are further milestones for 77 GHz ACC systems. This functionality is enabled by sensor fusion of 77 GHz LRR with UWB SRR based on 24 GHz UWB technology.

By definition, 77 GHz LRR sensors are optimized for a wide operating range and have a limited field of view, They are rarely used for near range applications due to a limited bandwidth of 1 GHz. (Source Autoliv)

Volvo has however announced single 77 GHz radar with short range capability in production in 2010 on the new Volvo S60. The system manufactured by Delphi enables ACC Stop&Go with Pre-crash safety/Emergency braking but also pedestrian protection and would be competitive for the mid-end vehicle segment.

2.6.3 Availability

77 GHz radar has been on the road since 1998.

The project KOKON has enabled some industry players to develop 77 GHz radars based on SiGe semiconductor technology. Bosch has put on the market a radar that uses this technology in the first semester of 2009. This development should enable a reduced price for this kind of radar.

2.6.4 Worldwide regulatory environment

The success of 77 GHz technology can be attributed to the availability of an almost globally harmonized 76–77 GHz band (about 100 countries) together with the advanced safety applications based on the combination with 24 GHz UWB SRR.

In Europe, the regulation enabling 77 GHz radars is given in Annex 5 of ERC/REC 70-03 for RTTT applications.

2.7 79 GHz UWB SRR

2.7.1 Industry stakeholders

Following Decision ECC/DEC/(04)03 in 2004 several companies are working on the development of 79 GHz technology and sensors as well as on the vehicle integration. This includes also companies which are today using 24 GHz UWB SRR and request a solution at 26 GHz.

Continental was the 1st company to demonstrate a SiGe-based 79 GHz SRR research sensor within the KOKON project. Achieving good resolution and high range at the same time is the benefit of 79 GHz SRR compared to 24 UWB (see Fig. 4).

Bosch focussed the effort and invested on the development for LRR / SRR in the range 76–77 GHz and 77–81 GHz and has announced substantial progress in the development of 79 GHz UWB SRR systems.

Daimler had the lead in the Germany funded project Kokon.

Investments have been realized in France within the framework of two projects (RADAR ACC and ARPOD).
(Source PSA)

Status of the radars components suppliers and costs
Several companies are working on the 79 GHz UWB SiGe BiCMOS technology in order to guarantee the availability of this technology from 2012/2013. We can quote:

1) Infineon who supplies the SiGe chips of the Bosch radar LLR3,
2) FreeScale who supplies a family SiGe chips integrating the locking buckle of phase (PLL) necessary for the synthesis of the emitted frequencies,
3) Fujitsu Ten which develops SiGe or CMOS chips for its radars,
4) STMicroelectronic

(Source PSA)

The figure below provides an overview of the suppliers which have made substantial investments on 79 GHz UWB technology.

Companie's name	Tier One	Tier Two	Tier Three
TRW	X		
Bosch	X		
Continental	X		
Denso	X		
MAGNA	X		
Autocruise (TRW)		X	
Fujitsu Ten		X	X
Hitachi		X	X
Freescale			X
Infineon			X
UMS			X
ST Microelectronics			X
TriQuint			X
Tier One: Integration of all type of applications (pre-crash, blind spot, …)			
Tier Two: Radar suppliers			
Tier Three: Radar chips suppliers			

Figure 12: Overview of suppliers working on the 79 GHz UWB (Source PSA)

2.7.2 Key features and enabled applications

The intrinsic advantages of 79 GHz UWB SRR are well described in the Report from CEPT in response to Part 1 of the new EC mandate on SRR (CEPT Report 36). The combination of 76-77 GHz and 77-81 GHz (like the combination of 24-24.25 GHz (NB) and 24.25-29 GHz (SRR)) using the same basic technology will enable the full range coverage (long, medium and short) required for automotive applications.

Bosch has stated that:

- Only with a homogenous technology concept large mass market deployment and a sound business case is possible
- The only reasonable technology platform to serve both short or mid and long range performance requirements is at 77 & 79 GHz
- The 77 / 79 GHz technology can cover the full safety system concept with best scale of economics and longest sustainability

- The current heterogeneous landscape (24 GHz NB, 24 / 26 GHz UWB,…) makes sense during today’s market proliferation phase and will keep radar based safety automotive systems on the road for the time being.

Other companies have another view on technology platforms and already use different sensors for different applications. The choice of the kind of sensor depends on the application. Combining Long Range Sensors (77 GHz) and Short Range Sensors (24/26 GHz) serve safety applications and highway scenarios as well.

2.7.3 Availability

There are no 79 GHz UWB sensors readily available today for vehicle integration. There is however a development programme: RoCC (Radar on Chips for Cars). This project involves Daimler, BMW, Bosch, Infineon and Continental (financed by the German government). RoCC is targeted to further advance silicon-based radar technology in the 76 – 81 GHz band with special emphasis on SRR. The final goal is to bring down the cost of 79 GHz automotive radar sensors significantly and make them cost-competitive to 24 GHz systems, thus enabling enhanced and affordable road safety for everyone. This project has started in 2009 and is expected to last 3 years.

One should note that a previous development project for 77 GHz radar (KOKON) has led to the placing on the market of LRR3 77 GHz radar with SiGe technology by Bosch in 2009.

Based on the research sensor realised in KOKON, Continental currently sees the following main blocking points for a short-term introduction of 79 GHz SRR:

- SRR sensors are often integrated directly into the plastic bumper, which has a poor heat conductance. The high power consumption of today´s 79 GHz SiGe chip sets makes integration into the bumper challenging.
- While today’s bumpers and automotive paint have a moderate attenuation for 24 GHz radar, the attenuation rises dramatically when migrating to 79 GHz due to the non-optimized adaption to that frequency. Integration of a 79 GHz sensor in a state-of-the-art bumper is not possible today, especially using today’s bumper paint repair techniques. Both issues are under investigation in the RoCC project.
- 79 GHz UWB is currently authorized in the EU and Singapore only. The present unavailability of a globally harmonized 79 GHz band makes 79 GHz sensor development very expensive. 79 GHz sensor development suffers under the missing global harmonization. However, it should also be noted that much of this spectrum (78-81 GHz) does have a worldwide primary Radiolocation allocation.

(Source Continental)

BOSCH is already using SiGe technology within the 2009 based LRR3 radar sensor and claims that these MMIC building blocks are ready for 79 GHz UWB SRR as well. The following is quoted from a submission by Bosch to WG FM meeting in May 2009:

- 77 GHz SiGe technology is in series production and installed in cars of two European premium vehicle manufacturers
- 77 GHz and 79 GHz technology is identical
- Certified modules and sensors for 79 GHz available appr. 2012 / 2013
- Prototypes are available today on request
- 79 GHz is expected to become cost comparable 24 GHz but will gain at the same time higher performance
- Bosch has followed the EC and CEPT recommendation in 2004
- Independent of the availability of radar technology at 79 GHz it is recognized by Bosch that there is a possible gap in the availability of SRR in cars of vehicle manufacturer for a few years.

(Source Bosch)

For SARA, the cost of sensors still creates a barrier to widespread use of 79 GHz UWB SRR: “The cost of these sensors (77 GHz LRR) however is still high which prevents development of vehicle applications that require several sensors needed for further safety functions in addition to comfort functions”.

To General Motors’ knowledge there is no 79 GHz road ready radar sensor available from automotive suppliers for evaluation on a vehicle. This required move to the 79 GHz band in 2013 will eliminate short range radar sensors from consideration in future active safety system development for the European marketplace in the foreseeable future. (Source GM)

Research and development work has also been undertaken for 79 GHz UWB SRR technology within the framework of two projects (RADAR ACC and ARPOD) financed by the general delegation of the French equipment (DGE) in complement to internal PSA Peugeot Citroën Automobile works. The RADAR ACC project involves also TRW radar sensors Company. The ARPOD project involves also TRW and Faurecia, which is a supplier for the automotive industry including of bumper material.

The RADAR ACC project, started in January 2007 and ending in the year 2010 is focused in developing a sensor capable of answering at the same time the specifications of the ACC, the pre-crash and the collision mitigation with the 76 GHz / 79 GHz UWB technology.

The ARPOD project, started in June 2009 and ending at the middle of 2012, is focused in answering to the peripheral performances of the vehicle (example LCA, BSD, side FCW, Pre-Crash) by mean of the development of sensors with the 76 GHz / 79 GHz technology and materials bumper adapted.

The prototypes sensors and pre-series sensors based on the 76 GHz SiGe technology targeted 79 GHz UWB technology are ready at the suppliers of radars (example Bosch, TRW, Fujitsu).

Concerning the status on the integration of the 76 GHz / 79 GHz technology in a vehicle, PSA has indicated that the transmission losses are connected to the constitution of the primers as well as to the pigmentation of certain paint loaded by metallic particles. The issues of bumper paints and material are already resolved and the solutions in order to reduce transmission losses below 2 dBs are also known. In addition, it was also shown within KOKON project that even metallic paintings with very large permittivity will not influence the radar operation inordinately, if certain design rules are applied. By varying the substrate thickness, it is possible to find a setup with a reflection coefficient of less than -20 dB in a very broad frequency band even for paint permittivity as high as $\varepsilon_r > 80$ (this result comes from the document published in 2009 “from 79 GHz UWB automotive short range radar – Spectrum allocation and technology trends, Advanced Radio Science., 7, pages 61–65, 2009” which can be found at http://www.adv-radio-sci.net/7/61/2009/ars-7-61-2009.pdf).

By contrasts, SARA notes that some car makers using 77 GHz for short range applications use special bumper materials and have no paint in front of the sensors. This shows that for some manufacturers there is still significant work to be done for the integration issue to make 79 GHz SRR possible in the cars. Further, heat dissipation of sensors integrated into bumpers is still a challenge. These outstanding issues indicate that for some manufacturers there remains significant work to be done before 79 GHz SRR can be integrated into cars. The results in KOKON (which SARA members are leading) are very initial research results, which must be verified and further developed in order for this technology to be certified for mass production applications. Manufacturers that have experience with integrating SRR into car production lines consider that these issues will not be resolved before the 24 GHz deadline expires.

Their validation (integration in the vehicle and functional response of the vehicle) is in progress within the framework of the two projects quoted previously and within internal PSA Peugeot Citroën works with promising results. PSA consider that the 76 GHz / 79 GHz UWB technology is already ready and its validation in a vehicle will also be ready from the 1st July, 2013.

The validation of the 79 GHz UWB which is based on the same SiGe 76 GHz technology can always be made gradually after 2013 by cars manufacturers which haven’t taken care in developing a strategy going towards the democratization of the technology 76 GHz / 79 GHz UWB. (Source PSA)

Compared to this, the Germany funded projects Kokon developed the SiGe technology at Infineon. (It should be mentioned that Bosch uses SiGe chipsets developed in Kokon for its new generation of ACC sensors.) The successor project RoCC is addressing the sensor development and also the integration issue (which includes bumper material and paint). Bumper materials and paints are still under development.

These open issues are the background that the 79 GHz is assessed by some car manufacturers to be not in time for a seamless transition in 2013 from 24 GHz to 79 GHz sensors in the vehicle.

2.7.4 Worldwide regulatory environment

79 GHz UWB SRR are only authorized in EU and Singapore. While the ITU radio regulations contain global radiolocation allocations for most of this band, much of the world has no specific spectrum regulation allowing 79 GHz UWB SRR.

At this time the 77-81 GHz band is not allowed in the US and Japan. Bosch indicated that they have started necessary activities to promote this regulation in the US and that the availability of 79 GHz regulation in the US is expected by 2013.

SARA initiated a request for a 79 GHz UWB SRR allocation in Japan in 2007. The 79 GHz process started in March 2010 directly after finalizing the process for 24/26 GHz. SARA is engaged in this process. On invitation by MIC of Japan, SARA presented the European 79 GHz UWB SRR regulation in the 79 GHz kick-off meeting in Tokyo on 8 March 2010 and participated in a follow-up meeting on 11 March 2010. MIC recognizes SARA as the representative of the European Automotive Industry on this matter.

Recently in Japan, after the decision of opening the temporary ranges 24/26 GHz, a study group has been created for the opening of 79 GHz. The first meeting was held on Feb. 8, 2010, with the attendance of Japanese carmakers (Toyota, Honda, Nissan) and suppliers (Hitachi, Fujitsu, Denso, Sumitomo Electric, NEC, etc.) as well as JAIA. These companies involved in this process have strong interest in 79 GHz. It was reported that these activities are supported by MIC.

As underlined in the Report from CEPT in response to Part 1 of the new EC mandate on SRR, a very important issue is worldwide harmonization of the frequency allocation for 79 GHz (77-81 GHz) as a precondition for successful market development.

3 REVIEW OF REGULATORY OPTIONS

The following policy options, which are not necessarily mutually exclusive, have been identified under Stage 3 of the IA:

- Option A: Keep current regulatory framework as it is / no change
- Option B: SRR systems in the frequency band 24-29 GHz (26 GHz UWB SRR)
- Option C: 24 GHz narrow-band radar systems (NB-24GHz) with extended band mode (WLAM)

The ACEA has expressed the view that, in general, spectrum availability and the related regulatory provisions should not hinder particular market solutions, as long as they are compatible with existing services and applications. ACEA in a subsequent communication noted that its response should normally be applied for all spectrum regulation. Its members do not have a common position on a particular regulatory provision, however, and thus it does not support a specific approach.

It should also be noted that there is a broad convergence of views on the mid to long term technology choice for SRR. Indeed 79 GHz UWB SRR is recognized to be the most favourable technology both from a technical and regulatory point of view. There is however strong disagreements on how to reach mass market deployment for this technology. Therefore for each of the options that were studied the case for and against is explained.

Within CEPT there is also support for the concept of permitting different automotive radar systems in different bands but this concept needs to take into account the need to ensure the efficient use of the radio spectrum and the avoidance of harmful interference or other public interest requirements. Because of the ubiquitous nature of these devices, the impact on radio systems needs to be carefully assessed. This is not a simple process and requires considerable investment in time and resources.

A further general point is that the existing regulatory framework for Automotive SRR has been formalised in Decisions at both the ECC and EC level (with the agreement of the relevant automotive stakeholders) to provide a suitable framework to allow SRR technology to make the transition from 24 GHz to 79 GHz. At that point in time it was believed that in 2013 a seamless transition to 79 GHz would be possible. As indicated in CEPT Report 3 adopted in July 2004, the 2013 reference date was derived from the envisaged vehicle parc penetration of SRR equipment of 7%, which was expected for 2013, as well as industry requirements for introduction of the equipment in a complete line of production while also taking into account the requirement for protection of the existing services in the 24 GHz range in accordance with the ECC Report 023. In addition, the reference date was defined so as to encourage SRR manufacturers to start at the earliest possible development of SRR at 79 GHz.

3.1 Option A: Keep current regulatory framework as it is / no change

Under this option it is expected that 24 GHz NB radars and 77 GHz radars will continue to be deployed and, presumably, encourage greater market acceptance by customers of road safety applications.

The impact of this option on 24 GHz UWB SRR is more profound (i.e. 24 GHz UWB SRR will no longer be permitted for sale in Europe from 2013). It is this 2013 cut-off date which has led SARA to express concern about an implementation gap and the possibility of market failure of automotive UWB SRR technology.

Comments in favour of option A:

Only a few companies have invested heavily in 24 GHz UWB. Most of the vehicle manufacturers including the companies using 24 GHz UWB SRR have a long-term strategy of 79 GHz. In the interim period other companies have decided not to use 24 GHz UWB SRR but instead to implement alternative technologies, mainly NB-24GHz and 77 GHz LRR with short range capabilities that provide many of the safety features of UWB SRR.

In support of Option A is the concern that any change in the existing agreed European package (i.e. something other than Option A) could undermine confidence in investment made in the development of sensor technology for operation in the 79 GHz frequency band, which has been identified by CEPT in 2004 as the most suitable band for long term development and deployment of automotive short-range radar. These investments should lead to the introduction of 79 GHz products within a relative short time frame. Assuming for instance 79 GHz UWB SRR by Bosch, TRW or MAGNA would be available around 2012/2013, production in car lines could start within the time frame 2014/2017 (when assuming a 2 – 4 year integration phase).

One vehicle manufacturer has stated that they consider that the 76 GHz / 79 GHz UWB sensor is already ready and its validation in a vehicle will also be ready from the 1st July, 2013. This suggests that the perceived technology gap may be possible to bridge without resorting to the 26 GHz band.

Finally, 79 GHz UWB SRR technology can be seen as an evolution of 77 GHz radar technology so there is little risk, under Option A, of this technology being abandoned and these manufacturers who have developed products in line with the long term goal of the initial European package should not be constrained.

Comments against option A:

Several companies (car manufacturers and suppliers) followed the intention of the European “Package Solution” to create benefits for road safety as soon as possible and invested in 24 GHz UWB SRR. SARA argues that, if there is no available UWB SRR in Europe after the cut off date of 2013, then industry stakeholders might choose other technologies competing with UWB SRR despite of the fact that these are limited in applications, have reduced functionality and less benefit for road safety. As a consequence, UWB SRR, its benefits on road safety could be substantially delayed and Europe could lose a technology lead.

Many manufacturers did not implement 24 GHz UWB SRR because of the 2013 deadline. Some of them use NB sensors, others are concentrating on the second part of the European package. Among these companies are also those which are using 24 GHz today. One of the companies which has invested in 24 GHz UWB SRR technology is Daimler which offers a full range of driving assistance and safety applications. This company and the others will be impacted by this Option, especially for the car lines that are already equipped with these safety features, but also for those it plans to launch in the near future. The view of these companies is that 79 GHz UWB SRR is not ready yet and a major change of technology by this car manufacturer would have to be decided as a matter of urgency and be implemented by 2013 so as to ensure continuity of these applications to their customers.

On the other hand some companies expect that the use of 26 GHz technology will accelerate the deployment of the 79 GHz sensors due to the fact that automotive applications are already available for the customer and create an increasing demand for UWB SRR. In consequence the market for UWB SRR would expand faster.

3.2 Option B: SRR systems in the frequency band 24-29 GHz (26 GHz UWB SRR)

Comments in favour of option B:

Proponents of option B have underlined that numerous companies already offer 24 GHz UWB SRR based vehicle applications (e.g. BMW, Daimler, Chrysler, Ford, Mazda, Volvo Trucks, and strongly interested: Fiat, Honda, GM as well as suppliers like Autoliv, Continental, Delphi, Furukawa, Visteon). The car manufacturers follow the intention of the European package solution to early offer vehicle applications. The benefit for road safety is already visible.

SARA recognized more than two years ago that UWB SRR will not be available continuously beyond the deadline of 24 GHz UWB SRR in 2013. SARA presented the request for a solution as a matter of urgency to CEPT and the European Commission.

Some stakeholders from the automotive industry who have invested in 24 GHz UWB SRR are now asking for the 26 GHz band to be used for UWB SRR. While these companies are also engaged in the development of 79 GHz solutions, they see the 26 GHz band as a substitute for 24 GHz as the sensors would be interchangeable. Relying on this technology to fill the predicted UWB gap would help develop the market for vehicle safety applications (safety for everyone). The high resolution offered by UWB technology enables object separation in complex road traffic scenarios. 26 GHz UWB SRR is already possible under the US and in Japan. This opens the chance for a worldwide harmonization.

Only Option B should allow the car makers using today 24 GHz UWB SRR (and being engaged also in the development of 79 GHz UWB SRR) to keep UWB SRR in the cars. It is the view of SARA that if UWB SRR would have to be designed out then UWB SRR may not come back for a significant period of time. Since most of these companies are technology leaders the deployment of 79 GHz could be also significantly delayed.

Competition between 26 GHz and 79 GHz sectors will bring cost down and make vehicle applications based on UWB SRR affordable for broad market segments, which supports the desired road safety benefits. The principle of technology neutrality supports the opening of the 26 GHz to UWB.

Comments against option B:

There are concerns about the possibility of using the 26 GHz band for UWB SRR. This band is heavily used in Europe for other services including fixed links, which provide network infrastructure for mobile and broadband mobile services and in some member states carries a wide range of communications traffic, including emergency traffic.

The difficulties faced in particular by industry players that invested in 24 GHz UWB SRR are due to a perceived delay in the availability of 79 GHz UWB SRR systems and should not be resolved by the designation of a new permanent frequency band for UWB SRR systems. Although system validation and integration of 79 GHz UWB SRR systems may indeed not be possible in time for a seamless transition in 2013, there is evidence that production in car lines could start within the time frame 2014/2017.

The proposal under option B may result in market fragmentation for UWB SRR sensors and could lead manufacturers and suppliers to question the strategies and investments made to develop 79 GHz UWB SRR technology, consistent with the initial European regulatory package adopted in 2004/2005.

If as proposed in option B, the 26 GHz UWB technology is allowed, the cost of 79 GHz UWB technology risks to increase significantly with regard to the cost planned at present time. According to some manufacturers, these additional costs are not insignificant for volume car manufacturers. The cost overrun will exclude them from safety applications and will not allow them to equip the whole range of vehicles including the low cost range which become more and more significant.

The concern about changing the European package, and undermining the confidence in moving to 79GHz which has been covered under Option A above, also applies here. Uncertainty over frequency bands could delay the development and subsequent deployment of this technology to well beyond 2013 and, consequently, the benefits to European industry from the development of this new technology will be reduced. The technological efforts set up to acquire 79 GHz UWB SRR technology is a long-term endeavour and investment will suffer from any uncertainty about this roadmap.

It is a widespread misunderstanding that technology neutrality means frequency neutrality i.e. that all possible frequency bands should be designated for a given application. Frequency management involves making decisions on the use of bands and technology neutrality implies that the decision on the technology to be used in a frequency band is left to those seeking to use spectrum. For example, the decision taken by the EC to allocate the 79 GHz band for permanent use for automotive radar means a market has been opened within which a technical neutral competition between vehicle manufacturers and suppliers can take place. If the 79 GHz automotive frequency band becomes available on a worldwide basis then this will accelerate the transition from other frequency bands.

3.3 Option C: 24 GHz narrow-band radar systems (NB-24GHz) with extended band mode (WLAM)

This Option offers improved performances for NB-24 GHz radars (see discussion under Option A) and will allow an easy upgrade for the many car-makers who validated the NB-24 GHz technology. It is recognized that 24 GHz NB technology is leading the rear-sensing market. NB-24 GHz technology is being introduced for front applications in competition with 77 GHz and UWB SRR technologies.

NB-24 GHz radars have reduced resolution due to limited bandwidth (200 MHz) and there are proposals by industry members such as VALEO and SMS to improve this with the WLAM concept so as to address some critical “pedestrian protection” scenarios. However, some competitors challenge the efficiency of such an approach which is seen to offer less resolution than the UWB equivalents.

SARA says that WLAM is not a substitute for UWB SRR and would not be able to bridge the gap in 2013.

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

SARA sees WLAM as a significant step from narrowband radar towards UWB SRR. It would provide a subset of automotive safety applications that are in direct competition to the wider range of applications provided by UWB radar. Option C therefore cannot be seen as complementary to existing regulations.

STAGE 7 - MONITORING AND EVALUATION

Monitoring on market penetration of 24 GHz UWB SRR systems should be continued until the cut-off date.

The future review of spectrum regulations for automotive radar applications would actually benefit from broader view of the effective deployment of collision mitigation and avoidance applications on road vehicles and of the technologies used to implement these technologies. It would be more appropriate for such monitoring measures to be conducted by the relevant EC body in charge of coordinating road safety policies at EU level, presumably in close co-operation with the ACEA.

CEPT investigations in response to the EC Mandate on SRR also reemphasizes the merits of existing spectrum regulation for 79 GHz UWB SRR systems and the need to support global harmonization. Beyond the possible initiatives taken within the automotive industry, the possibility for adequate actions by CEPT administrations at ITU level need to be investigated. It is also likely that coordinated actions at EU level need to be taken in order to promote Commission Decision 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 (2004/545/EC) towards major regional markets. Proper monitoring of the worldwide implementation of this regulation would stimulate such actions.

Appendix 1: Automotive radar applications

The following descriptions are taken from the link below, with additions to cover the list of applications used for the questionnaire.

http://ec.europa.eu/information_society/activities/intelligentcar/technologies/index_en.htm

Adaptive cruise control and stop and go

Adaptive Cruise Control (ACC) technology improves the function of standard cruise control by automatically adjusting the vehicle speed and distance to the vehicle ahead. This is achieved using a long range radar sensor, a signal processor and longitudinal control of the vehicle. If the vehicle ahead slows down, or if another object is detected, the ACC adjusts vehicle speed and headway accordingly without any action on the part of the driver. Once the road is clear, the system will re-accelerate the vehicle back to the set speed. As with standard cruise control, the driver can override the system at any time. The current ACC systems are mainly comfort functions with a limited speed range.

ACC with full speed range function will make the systems safer and even more convenient to use. If needed, the system will slow the vehicle down to a standstill, using its full braking power, instead of turning off at a certain speed as is presently the case. This system will also recognise when the car in front starts to move again and will announce this to the driver, usually by acoustic signal. Then the vehicle will accelerate automatically to the pre-selected speed while maintaining the correct distance to the vehicle ahead and adjust to the tempo of the traffic.
ACC stop and go is an extension of ACC to situations where traffic is heavy and vehicles are subject to frequent halts.

Lane change assistant/blind spot detection

The *Lane Change Assistant* or the *Blind Spot Detection* systems continuously monitor the rear blind spots on both sides of the vehicle. For example, before overtaking or changing lanes, the driver looks in the side mirror which confirms that the lane is free – but suddenly a car comes into the visual field from behind, just when the driver is about to change lanes. Such critical situations often arise in urban traffic and result in an accident if the vehicle in the blind spot is overlooked. When the turn signal is activated indicating that the driver is about to change lane, these systems warn the driver either visually or by discreet vibration of the steering wheel, if changing the lane is not safe at that moment.

Obstacle collision warning, collision mitigation/avoidance, pre-crash

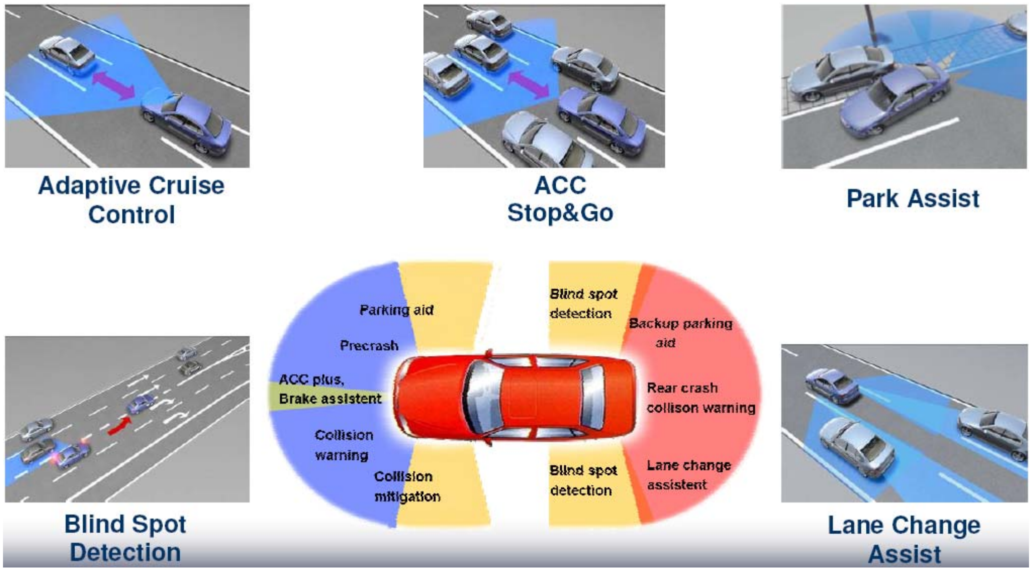
Obstacle / *Collision Warning* Systems help the driver to prevent or mitigate accidents by detecting vehicles or other obstacles on the road ahead and by warning the driver if a collision becomes imminent. Current solutions with limited performance are an additional function of Adaptive Cruise Control, using information obtained from radar sensors to give visual and acoustic warnings. Future systems will use long range/near range radar sensors or LIDAR and video image processing or a combination of these sensors.

In addition to warning the driver, the system can also pre-fill the braking system to provide full braking force (*braking assistance*) as soon as the driver applies the brakes, or pre-arm airbags or pre-tension seatbelts in order to prepare the vehicle for an imminent collision (*pre-crash passenger protection*). Furthermore the collision warning system can be used for active mitigation of collision with *emergency braking*. In this case the system can directly activate the brakes without the intervention of the driver if there is a risk of an unavoidable accident.

Pedestrian vulnerable road user protection (active and passive)

These are systems which help prevent collisions and protect vulnerable road users such as pedestrians and cyclists. The sensor systems (often a combination of several sensor types) monitor the area in front of the vehicle, reliably detect vulnerable road users and distinguish them from other obstacles. The system uses different actuators, such as autonomous braking/brake assist which help avoid collisions or significantly mitigate their impact by reducing the speed of the vehicle before the collision (*active pedestrian protection*). If a collision cannot be avoided, protective structural actuators can be triggered (e.g. airbags in the bumper, lifting the hood of the car etc.) which reduce the chance of serious injuries or even save the lives of vulnerable road users (*passive pedestrian protection*).

The above description is illustrated by the figure below:



Source SARA

Appendix 2: Applications table

Notes:

- No competitive information for these applications such as roadmaps is disclosed, so only information on the current availability on the market is enclosed. Car makers presently offering to the customer an application are indicated with a star in the table.
- According to car class or car line respectively performance requirements for each application can vary.
- This summary is base on the replies to the questionnaire and does not provide a complete picture as not all companies replied.

Applications		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. The table below 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?. *Note: where a vehicle manufacturer is marked an asterisk (*), it indicates that the application is in production.*
Pedestrian protection (Active)	Active pedestrian protection (active braking/brake assist)	Bosch: Mid Range Radar (77-81 GHz or 76-77 GHz depending on availability of globally harmonized frequency range) Daimler*: fusion of sensor data LRR and UWB SRR (frequency 76-77 GHz and 24 GHz UWB, 26,5 GHz planned) Continental: Radar systems based on UWB technology can be an essential part of pedestrian protection systems BMW: today the BMW group has no system on the market which triggers the brake through detection of pedestrians. However there is a passive system providing a warning on the display in the case a pedestrian is detected (this system is based on a far-infrared camera). Autoliv: UWB radar (UWB radar in fusion with camera of IR systems) PSA: radar multi-beam working within 24 GHz NB or 77 GHz NB (79 GHz) Valeo: data fusion between vision and ultrasonic for short range, extended range possible with NB 24 GHz radar if WLAM gets approval. General motors: 24-29 GHz UWB SRR and vision systems. JLR: 24 GHz narrow band for detection (+camera to classify pedestrians)
Pedestrian protection (Passive)	Passive pedestrian protection (e.g. activation of airbags in the bumper, lifting the hood of the car etc.)	Bosch: Mid Range Radar (77-81 GHz or 76-77 GHz) BMW*: far infra-red camera (provide a warning on the display in case a pedestrian is present) Autoliv: UWB radar (UWB radar in fusion with camera of IR systems) PSA: radar multi-beam working within 77-81 GHz (79 GHz) Valeo: data fusion between vision and ultrasonic for short range, extended range possible with NB 24 GHz radar if WLAM gets approval.
Pre-crash (passive safety)	Passenger protection (air bag arming…)	Bosch: LRR; 76-77 GHz combined with MRR; 77-81 GHz or 76-77 GHz depending on availability of globally harmonized frequency range Daimler*: fusion of sensor data LRR (76-77 GHz) and UWB SRR 24 GHz (26,5 GHz planned) Autoliv: UWB radar PSA: radar multi-beam working within 77-81 GHz (79 GHz) Valeo: ??? question unclear JLR: 77 GHz or 24 GHz
Collision	Emergency braking	Bosch: LRR (76-77 GHz); configuration with radar sensor and mono camera for verification. Bosch has provided info

mitigation/avoidance (active safety)		on its own LRR3 sensor (using the 76-77 GHz band). This sensor enables ACC and emergency braking. Daimler*: uses sensors LRR fusion of LRR and UWB SRR (24 or 26 GHz) Autoliv: Highway: UWB and LRR, urban environment: UWB radar PSA: radar multi-beam working within 24 GHz NB or 77 GHz NB (79 GHz) Valeo: RFQ on-going for NB 24 GHz radar systems based on low-cost ACC General motors: 76-77 GHz LRR, 24-29 GHz UWB SRR and vision systems. JLR: 77 GHz. Continental: delivering an emergency braking assist based on IR laser to an European OEM (Volvo) for low speeds.
	Braking assistance	see emergency braking
Collision warning	Emergency warning (front)	Bosch: LRR (76-77 GHz) Daimler*: used sensors: LRR (76-77 GHz) 26,5 GHz planned for Forward collision warning. BMW*: today 76-77 GHz radar is used Autoliv: Highway: UWB and LRR; urban environment: UWB radar PSA: radar multi-beam working within 24 GHz NB or 77 GHz NB (79 GHz) Valeo: NB 24 GHz in production General motors: 76-77 GHz LRR, JLR*: 77 GHz
	Emergency warning (rear closing vehicle)	Bosch: MRR (77-81 GHz or 76-77 GHz depending on availability of globally harmonized frequency range) Autoliv: UWB radar PSA: radar multi-beam working within 24 GHz NB or 77 GHz NB (79 GHz) Valeo: SOP planned before 2013 for rear pre-crash with NB 24 GHz LCA radars General motors: 24-29 GHz UWB SRR or 24 GHz Narrowband MRR JLR: 77 GHz or 24 GHz
	Emergency warning (cross traffic)	Bosch: MRR (77-81 GHz or 76-77 GHz depending on availability of globally harmonized frequency range) and camera BMW: today radar based technology is not used. Available is a video camera based image on display inside the vehicle to give driver the possibility to look into the left and right direction in front of his vehicle. Autoliv: UWB radar PSA: radar multi-beam working within 24 GHz NB or 77 GHz NB (79 GHz) Valeo: NB 24 GHz in production General motors: 24-29 GHz UWB SRR or 24 GHz Narrowband MRR JLR: 24 GHz Narrow band
	Lane change assist	Bosch: MRR (77-81 GHz or 76-77 GHz depending on availability of globally harmonized frequency range) BMW*: the system monitors the area on the neighbour lane and warns the driver if the lane is occupied (radar 24 GHz ISM) Autoliv: SRR and UWB radar

		PSA: radar multi-beam working within 24 GHz NB or 77 GHz NB (79 GHz) Valeo: NB 24 GHz in production General motors: 24-29 GHz UWB SRR or 24 GHz Narrowband MRR JLR: 24 GHz narrow band
	Blind spot detection	Bosch: see Lane Change assist Daimler*: use of two UWB SRR Continental: this application is being served by Continental using a 24 GHz UWB sensor since 2007 in non-European countries. Due to the 2013 sunset date for 24 GHz UWB SRR, this system has not been introduced on the European market so far. BMW*: see lane change assist Autoliv: SRR and UWB radar PSA: radar multi-beam working within 24 GHz NB or 77 GHz NB (79 GHz) Valeo: NB 24 GHz in production General motors*: 24-29 GHz UWB SRR or 24 GHz Narrowband MRR* JLR*: 24 GHz narrow band
Driving assistance	Adaptive Cruise control	Bosch: LRR (76-77 GHz) Daimler*: used sensor LRR (76-77 GHz) Continental: currently offers the 3rd generation of adaptive cruise control, based on 76-77 GHz technology BMW*: today 76-77 GHz radar is used Autoliv: LRR PSA: radar multi rays working within 77 NB -81 GHz (79 GHz) Valeo: Several NB 24 GHz suppliers are proposing low cost ACC to start serial development now General Motors*: 76-77 GHz LRR JLR*: 77 GHz
	ACC Stop and Go	Bosch: LRR (76-77 GHz) combined with other satellite sensors Daimler*: fusion of sensor data LRR (76-77 GHz) and UWB SRR (24 or 26 GHz) and camera (planned) Continental: stop and go function needs UWB technologies for full functionality. BMW*: today 76 GHz and 24 GHz UWB radar is used Autoliv: LRR in combination with UWB radar, early detection of a cut in (e.g. pedestrian or motorcyclist) requires UWB sensors. PSA: radar multi rays working within 77 NB -81 GHz (79 GHz) Valeo: RFQ on-going for NB 24 GHz radar systems based on low-cost ACC, (TRW proposes a 24 GHz based radar device that enables stop and go ACC). General motors: 76-77 GHz LRR JLR: 77 GHz wide field of view or 77 GHz narrow field of view with 24 GHz
Parking assistance	Parking Assistance	Bosch: ultrasonic sensors

		Daimler*: currently ultrasonic sensors are used in a majority of cases (if radar is used 24 GHz UWB SRR) Continental: parking applications (if based on radar) need UWB technology BMW: ultra sonic sensors Autoliv: UWB sensors PSA: no need of radar Valeo: 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) General motors*: Ultrasonic and/or 24-29 GHz SRR. JLR*: ultrasonic sensors only
Other?		

ANNEX 3: PROPOSAL FOR AN EXTENSION OF THE 24 GHz UWB SRR AGREEMENT

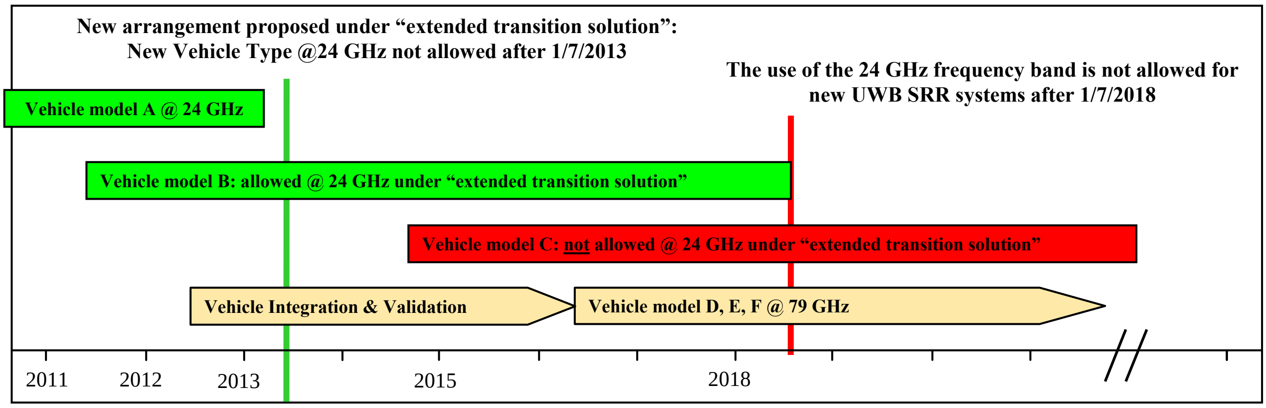
Some administrations within CEPT are of the opinion that a transition to 79 GHz can be facilitated by extending the existing 24 GHz agreement but with some modifications to the terms of that agreement. The key features for an "extended transition solution for 24 GHz UWB SRR systems" are presented here below:

1. Technical requirements for 24 GHz UWB SRR systems:

The technical regulatory parameters would remain unchanged:

- maximum mean e.i.r.p. density of -41,3 dBm/MHz in the frequency band 21,65 – 26,65 GHz
- vertical attenuation of 30 dB (for emissions ≥30° above the horizontal plan in the band 23,6 – 24 GHz)
- automatic deactivation…

2. Description of the extended transition scenario



Key regulatory features:

- Derogatory measure intended to vehicle manufacturers which have already implemented 24 GHz UWB SRR in existing vehicle product lines;
- **New Vehicle Types** not allowed to be equipped with 24 GHz UWB SRR systems after **1/7/2013**;
- The 24 GHz frequency band may only be used within CEPT countries for new UWB SRR systems until **1/7/2018**;
- Maximum penetration rate of **0,2%**

3. Compatibility with radio services

3.1 Fixed Service

Compatibility with the Fixed Service would be ensured by the maximum penetration rate of 0,2% which is well below the 10% figure resulting from the studies in ECC Report 023 and even below the 1% figure applicable to worst cases studied in ECC Report 023.

3.2 Radio Astronomy Service.

Regulatory provisions associated with automatic deactivation presented in Decision ECC/DEC/(04)10 (see decides 5) and Commission decision 2005/50/EC (see Article 6) shall apply in order to ensure the protection of the Radio Astronomy Service.

3.3 Earth exploration-satellite service (EESS)

The proposal for an extension of the 24 GHz UWB SRR agreement addresses the transition issue faced by some vehicle manufacturers which have already implemented 24 GHz UWB SRR in existing vehicle product lines. In view of this objective for an extended interim solution and taking into account the above figures, a **maximum penetration rate of 0,2% could be supported by some administrations.**

The analysis presented in CEPT Report 36 provides actually strong justification for not modifying the existing regulation for 24 GHz UWB SRR systems, taking into account in particular the conclusions from the ITU-R studies leading to a maximum penetration rate of 0,031% which is required for the protection of the 23.6-24 GHz EESS(passive) band on long term basis.

The ITU-R TG1/8 has concluded the following.

> *The result of interference analysis using specific EESS systems characteristics or generic methodology, concludes that a 100% deployment of SRR operating at 24 GHz results in interference exceeding the EESS threshold up to 35 dB with a 1% apportionment of the interference criteria.*

According to this conclusion, it means that the required SRR at 24 GHz eirp equals -76.3 dBm/MHz along with a 35 dB attenuation antenna gain above 35°. It can be noted that the negative margin of -35 dB is translated into a maximum penetration rate of 0.031%.

Due to the major policy objectives supported by EESS operational activities, a strict monitoring mechanism should be maintained.

Concerning the protection of the passive band 23.6-24 GHz from unwanted emissions derived from SRR operating at 26 GHz, it has been agreed the following (as noted within the draft ECC Report (*The impact of 26 GHz SRR Applications using Ultra-Wideband /UWB) Technology on Radio Services)*).

> *Technical discussions and studies have concluded to the following compromise concerning the protection of the passive band 23.6-24 GHz from out of band emissions from SRR operating at 26 GHz:*
> - *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 order to protect the Radio Astronomy Service, it has been agreed that a level of -74 dBm/MHz e.i.r.p is proposed instead of a -73 dBm/MHz.

Based on the approved ITU-R TG1/8 Report and Recommendations, it can be concluded the combination of the -73 dBm/MHz and the 20 dB attenuation antenna gain above 30° leads to a negative margin of 2.6 dB for nadir satellite systems and of 5.4 dB for conical satellite systems. These results are derived from tables 255 and 256 of ITU-R Report SM.2057.

Then, taking into account these negative margins along with a 30 dB attenuation antenna gain, the corresponding maximum penetration rates range between 0.1% and 0.12% for nadir satellite sensors, and between 0.1% and 0.23% for conical sensors.

Therefore, for SRR at 24 GHz, assuming a -41.3 dBm/MHz maximum EIRP and a 30 dB attenuation antenna gain, a **maximum penetration rate of 0.2 %** may be acceptable hence providing **a level of protection to EESS (passive) equivalent to the level of protection afforded from SRR possibly operating at 26 GHz**.

The scientific community (ESA-EUMETSAT-EUMETNET-CRAF) expressed however serious concerns about this solution and strongly oppose this 24 GHz extension, in particular since it would represent a new breach in the imperious protection of this essential frequency band covered by RR N° **5.340**. To this respect, these organisations highlight the fact that, whatever the conditions and date of this extension, it would be in total contradiction with RSPG Opinion on "**a Coordinated EU Spectrum Approach for Scientific Use of Radio Spectrum**" and in particular its provision 9.5", stating:

> *"The RSPG considers that these represent essential natural resources and urges Member States to respect their obligations under No. 5.340 of the Radio Regulations, which prohibits all emissions in the corresponding frequency bands. The RSPG recommends the EC, when preparing appropriate measures on spectrum, to support the needs of the scientific services in these particular bands."*

Last but not least, ESA-EUMETSAT-EUMETNET-CRAF do not understand how such cut-off date extension of SRR 24 GHz could be considered, that would obviously lead to an incompatibility between SRR and passive sensing when on the other hand compatibility exists in the 26 GHz with all allocated services as outlined in the present CEPT Report 37. Thus there would be no rational reason for favouring an extension of the 24 GHz SRR use over a 26 GHz SRR temporary solution for the same period of time.

It is to be noted that this solution is not supported by any of the stakeholders, neither the scientific community nor the automotive community.

4. Perspectives for the automotive industry

<u>Comments supporting prolongation</u>

Some administrations, seeking to offer a compromise, have proposed prolongation based on an "extension of the 24 GHz UWB SRR agreement" offering a transition solution that accounts for key constraints in production cycles of the automotive industry for the introduction of new vehicle models in the short term. A new vehicle model equipped at 24 GHz certified e.g. in 2011 could be commercialised until 1/7/2018 under this interim derogatory measure.

It offers the perspective for the market basis to rise from 0,02% penetration in Europe (May 2009) reported by SARA to a maximum of 0,2%.

Out of a total European fleet in the order of 200 millions of vehicles (EU15), 0,2% represents a total fleet of 400 000 vehicles that could be equipped with 24 GHz UWB SRR systems in Europe.

Assuming the market share of the vehicle manufacturers having already implemented 24 GHz UWB SRR systems and requiring a transition solution is in the order of 5%, a maximum penetration rate of 0,2% would in practice allow the vehicle manufacturers addressing only the "executive car" segment.

The general strategy regarding the interim (24 GHz) and long term (79 GHz) solutions would in principle remain unchanged and vehicle manufacturers could focus on the 79 GHz frequency band for the introduction of UWB SRR systems on a large scale and long term basis.

<u>Comments opposing prolongation</u>

Some other administrations and SARA opposed the proposed prolongation. They consider that the proposed regulatory features as outlined in section 2 of this annex do not meet the constraints of the automotive industry, as explained below.

SARA stated that there is no automotive company that supports prolongation of the 24 GHz approach and SARA also stated that industry stakeholders consider that this alternative is not useable. SARA points out that it seeks a bridge solution to reach a long term 79 GHz solution. This approach is shown in figure 1 demonstrating that the 26 GHz option would permit this solution.

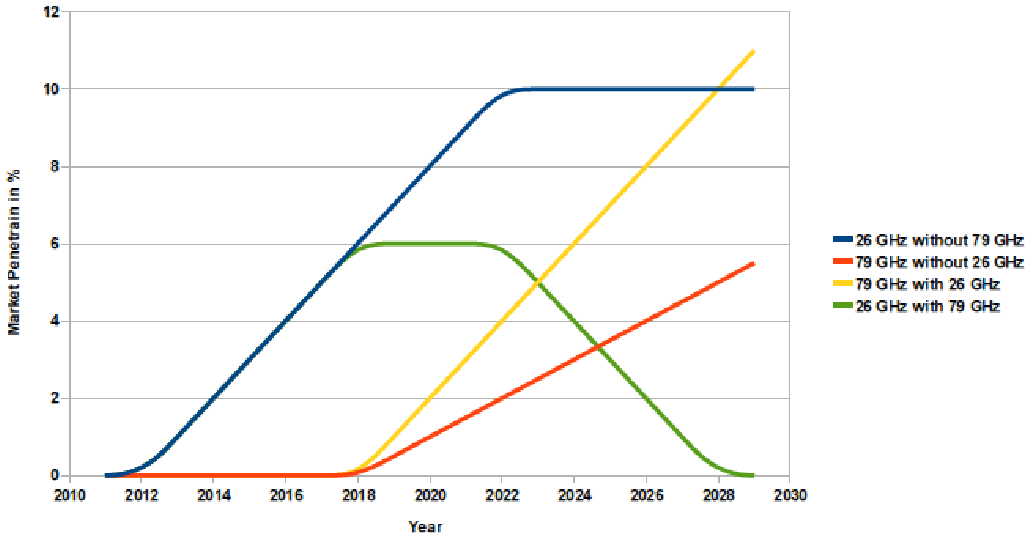


Figure 1: 26 GHz will be a bridge solution and also develop the market for 79 GHz UWB SRR

Industry has noted that prolongation of 24 GHz technology is of no use to the automotive industry:

- The gap for implementation of 79 GHz technology would remain.
- UWB SRR for <u>new</u> car lines would be stopped immediately. Only car lines already in production will be produced until the end of their production time.

- No car maker in Europe could implement or design new product lines using the extended 24 GHz band alternative because of the long development and production cycles.
- UWB SRR will be stopped for many years. Car makers will use other technologies because two sensor lines in parallel – 24 GHz for Europe and 26 GHz for US and Japan - are economically not feasible.
- Volume car lines could not use 24 GHz UWB SRR. 24 GHz SRR remains subject to automatic deactivation, which makes the applications too expensive.

The result will be that eSafety goals will not be achieved. Prolongation would not help with broader take-up of UWB SRR to equip additional (and volume) car lines. Also no new car makers could use UWB SRR until 79 GHz will be available. (For example, Renault announced a car line with 79 GHz, but not until the year 2017 (under conditions). 12 years will be lost for road safety (from 2005 – 24 GHz designation to 2017 launch Renault.)

Moreover, this approach is inconsistent with the arguments of those automotive makers who are concerned about market fragmentation – if 24 GHz technology is continued and used, it also will fragment the market.

On the other hand 26 GHz has significant advantages also for 79 GHz market take up as well as for other frequency users as shown in the following comparison:

	Interim solution at 24 GHz	**Bridge/interim solution at 26 GHz**	**DIFFERENCE in favour of 26 GHz**
FS	-41 dBm/MHz	- 50 dBm/MHz	9 dBm/MHz
EESS/RAS emissions into passive band	-41 dBm/MHz	-74 dBm/MHz	33 dBm/MHz
Automatic deactivation for RAS	Automatic deactivation required	No automatic deactivation required	Also volume car lines could be equipped with significant, benefit for road safety
Number of sensor lines	2 (one sensor for Europe, one sensor for Rest of World in parallel)	1 (one sensor worldwide)	2 sensor lines in parallel are not affordable for the industry.

Table 1: Comparison of the consequences of the different approaches – Prolongation of 24 GHz vs. bridge/interim solution at 26 GHz (Source SARA)

In sum, there is an industry demand for 26 GHz technology – there is no demand for technology prolongation at 24 GHz. Prolongation of 24 GHz is of no use to anybody. SARA maintains that this alternative serves no purpose and cures no problems.

ANNEX 4: LIST OF REFERENCES

[1] EC Decision 2005/50/EC: Commission Decision 2005/50/EC on the harmonisation of the 24 GHz range radio spectrum band for the time-limited use by automotive short-range radar equipment in the Community

[2] 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) amended 5 September 2007

[3] EC Decision 2004/545/EC: Commission Decision 2004/545/EC on the harmonisation of radio spectrum in the 79 GHz range for the use of automotive short-range radar equipment in the Community

[4] 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

[5] CEPT Report 36: Report from CEPT to the European Commission in response to Part 1 of the Mandate on Short Range Radar

[6] ETSI TR 102 664: Short range radar to be used in the 24 GHz to 29 GHz band

[7] ETSI TR 102 892 V1.1.1_005 (2010-02): SRD radar equipment using WLAM (Low Activity Mode) and operating in the frequency range from 24,05 GHz to 24,50 GHz

[8] ERC Report 025: The European table of frequency allocations and utilisations covering the frequency range 9 kHz to 275 GHz

[9] ERC/REC 70-03: Short Range Devices (SRD)

[10] ECC Report 023: Compatibility of automotive collision warning Short Range Radar operating at 24 GHz with FS, EESS and Radio Astronomy

[11] ITU-R Report SM.2057: Studies related to the impact of devices using ultra-wideband technology on radiocommunication services

[12] Recommendation ITU-R F.1101: Requirements for point-to-multipoint radio systems used in the local grade portion of an ISDN connection