CEPT Report 36

Report from CEPT to the European Commission in response to Part 1 of the Mandate on

”Automotive Short Range Radar systems (SRR)”

Final Report on 25 June 2010 by the

Electronic Communications Committee

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

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1 INTRODUCTION

This report by the European Conference of Postal and Telecommunications Administrations (CEPT) to the European Commission (EC) has been developed in response to Part 1 of the Mandate to CEPT to undertake Technical studies on automotive short-range radar systems (SRR).

The new EC Mandate on SRR calls for the delivery in October 2009 of a *Final Report from CEPT to the Commission on Part 1 of the mandate, subject to public consultation.*

The new EC Mandate on SRR identifies 3 separate tasks under 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[1] ;

- 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.

This report was developed within WG FM and approved by the ECC at its meeting in October 2009, subject to public consultation. The comments received from one vehicle manufacturer during the public consultation were considered when finalizing this Report. ECC at its meeting in June 2010 finally approved this report for publication.

2 ANALYSIS

2.1 Review of initial technical assumptions in compatibility studies on SRR 24G

The review of initial technical assumptions in compatibility studies on SRR 24 GHz is given in **Annex 1** to this report.

Based on the analysis in this Report, simply by taking into account the constraints resulting from coexistence between SRR 24 GHz and EESS, & Radio Astronomy, CEPT can conclude that existing regulation for SRR 24GHz systems should principle be kept without substantial changes. CEPT agreed however that further consideration could be given on the status of existing regulation for SRR 24GHz systems with the frame of discussions in response to part 2 of the EC Mandate on SRR (see CEPT Report 37).

In addition to these technical justifications, it has to be recalled that the 23.6-24 GHz band is protected by the footnote No. 5.340 of the Radio Regulations which states that '*all emissions are prohibited*'. RSPG opinion developed in October 2006 about the scientific use of radio spectrum mentioned that '*In particular, the RSPG urges Member States to respect their obligations under No. 5.340 of the Radio regulations and recommends the EC, when preparing spectrum measures, to support the needs of the scientific services in these particular bands.*'. Therefore, it would also be consistent to confirm that no new SRR24 GHz systems can be allowed also from a regulatory point of view.

Concerning the coexistence between SRR systems and FS in the 23 GHz (22-23.6 GHz), 26 GHz (24.5-26.5 GHz), 28 (27.5 – 29.5GHz) and 32GHz (31.8 – 33.4GHz) frequency bands, several comments have been made on the assumptions used in ECC Report 23 and the relevance to the two FS deployment scenarios (Scenario 1 & 2) considered in ITU-R Task Group 1/8 studies. It was noted that the technical studies contained in ECC Report 23 and the European Regulatory framework contained EC Decision 2005/50/EC for 24GHz SRR were submitted to ITU-R Task Group 1/8 and formed part of extensive discussions that lead to adoption of ITU-R Recommendation ITU-R SM.1756 and ITU-R Report SM.2057. Recommendation SM.1756 includes the European regulatory framework and Report SM.2057 takes account of European FS deployment practices. There is no substantial difference in conclusions between the ECC and ITU-R work - both lead to the conclusion of SRR/FS incompatibility in the long term

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

2.2 Review of development of SRR 79G

The review of development of SRR 79G is given in **Annex 2** to this report.

The regulatory package on SRR systems adopted in 2004 called for a general review to take place in 2009. This analysis aims to review the development of 79 GHz technology and to assess more generally the continuing relevance of existing regulation for SRR 79GHz systems.

These initial investigations under this new EC Mandate on SRR underline that today's SRR sensor technology uses SRR operating at 24 GHz giving for the first time the opportunity to develop vehicle applications for object detection in the vicinity of a car, making a new generation of automotive safety systems possible.

Future safety and comfort applications for vehicles will benefit from higher sensor performance at smaller size. Pushed by significant progress in Silicon based MMIC technologies and low cost packaging capabilities 79 GHz short range radar is in the process of becoming cost-competitive and affordable. It is recognized that the 79 GHz solution is a long-lasting solution for all vehicle manufacturers to improve active safety devices.

The European frequency regulation currently requires SRR to migrate from 24 GHz to 79 GHz spectrum in the year 2013. The system integration and validation of 79 GHz technology may not be possible in time for a seamless transition. According to SARA, a phase of car integration and extensive car tests will require additional several years in order to ensure that all safety aspects are correctly implemented. The technology to be used in a car line must be fixed several years before start of production (SOP). For instance, car lines with SOP in 2013 were fixed in 2008. Thus, sensors must be mature now to be integrated into car production lines by 2013. During the public consultation of this report, it was however 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 manufacturer. According to this respondent, this validation will be ended before the deadline of the 1st July, 2013 and this technology will be marketed extensively in the line of product of that car manufacturer from 2014/2015.

Not all car manufacturers who sell products in Europe have plans to include 79 GHz SRR products into their production lines before 2013. One radar manufacturer has stated that 76 GHz products are in use by several European car manufacturers today and 79 GHz products are almost identical. This radar manufacturer expects to have certified modules and sensors for the 79GHz band available around 2012-13. SARA underlined that the car manufacturers need sufficient time for vehicle integration including development of bumper materials and paints as well as extensive tests for safety applications.
The net result is that independent of the availability of these radar technologies at 79 GHz today, there is a possibility that there may be a gap in the availability of SRR in new cars being placed on the European market after the 24GHz band is no longer available for use in 2013. During the public consultation of this report, it was however observed by one respondent that the problems associated with paints will be resolved before the deadline of the 1st July, 2013.

It is also important for the 79 GHz SRR market growth that availability of a worldwide harmonised frequency allocation is possible. Europe should encourage other markets such as North America and Japan to adopt the same band as the European allocation. In this case Economies of scale would bring costs down, which in turn should expand opportunities for 79 GHz SRR becoming an affordable technology as a mid- and long term solution worldwide with the broad benefits for road safety in Europe that this will bring.

2.3 Considerations on the results of Commission's Call to stakeholders

The results of the Call for Input of the European Commission were made available during WG FM meeting in February 2008 and were briefly considered. These comments raised a number of issues including sharing difficulties with existing services and consideration of alternative technologies to SRR which would need to be considered further. The newly established WG FM Protect Team FM47 was tasked to further consider these comments.

3 ORIENTATION FOR FUTURE WORK

Proposed "overall work plan on SRR" given in **Annex 3** to this document.

The work plan identifies 4 main working periods paced by WGFM meeting schedules where draft deliverables from the group on UWB need to be approved.

- December 2008 / January 2009
- February / May 2009
- June / September 2009
- October 2009 / January 2010

Beyond the formal deliveries requested under the (new) EC Mandate on SRR, it identifies two main studies needed in support of this work:

- Compatibility studies if required on SRR in the frequency range **24 – 29 GHz** (referred to in this document as **SRR 26G** for sake of convenience);
- Assessment of automotive SRR.

An assessment of automotive SRR (see guidance in ECC Report 125) is proposed to be developed as the main tool for consolidated analysis in view of final decision making, especially on the possibility to allow alternative bands for SRR systems and consideration of alternative technologies to SRR, and should be developed in parallel by WGFM Project Team FM47 on UWB.

ANNEX 1: REVIEW OF INITIAL TECHNICAL ASSUMPTIONS IN COMPATIBILITY STUDIES ON SRR 24GHz

1 INTRODUCTION

ECC Report 23 considers the impact of automotive Short Range Radars (SRR) on allocated radiocommunication services operating in the frequency range 21 to 27 GHz. The study has focused on 3 specific primary services to which SRR 24GHz has been considered likely to present a high interference potential:

- Fixed Service (FS)
- Earth Exploration Satellite Service (EESS)
- Radio Astronomy Service (RAS).

The impact of SRR 24GHz on Radar Speed Meters (RSM) was also considered in the context of the first EC Mandate on SRR (see CEPT Report 3). Further investigations concerning the use of the band 24.05 – 24.25 GHz currently take place within the work on Short Range Devices.

This analysis recalls the main technical and operational characteristics of SRR 24GHz, as well as the conclusions of compatibility studies detailed in ECC Report 23 and ITU-R Report SM.2057.

A review of the continuing relevance of the technical assumptions used in these compatibility studies is then carried out.

Finally, a conclusion at this time is proposed on whether the existing regulations for SRR 24GHz need to be revised or not, as well as on other possible implications of this analysis within the context of the new EC Mandate to CEPT on automotive short-range radar systems (SRR).

2 CHARACTERISTICS OF SRR 24GHz SYSTEMS

SRR units operating at 24 GHz require an operating range of up to 30 meters and are used for a number of applications to enhance the active and passive safety for all kind of road users. Applications that enhance passive safety include obstacle avoidance, collision warning, lane departure warning, lane change aid, blind spot detection, parking aid and airbag arming. SRR applications, which enhance active safety, include stop and follow, stop and go, autonomous braking, firing of restraint systems and pedestrian protection.

The 24 GHz SRR is a combination of two functions:

- a high resolution distance measurement to provide speed information of an approaching object using Doppler radar. This necessitates a narrow band +20 dBm peak signal with a mean power level of 0 dBm. All wanted emissions associated with the necessary bandwidth are inside the SRD band (24.05 to 24.25 GHz), as given in CEPT Recommendation 70-03.
- a wide band radar to provide information of the position of objects with a high resolution of approximately 10-15 cm and requires an average spectral power density of -41.3 dBm/MHz or -103.3 dBm/Hz, spread approximately ± 2.5 GHz centred on the SRD band at 24 GHz. Emissions outside of this mask are at least a further 20 dB down i.e. -50 or -110 dBm respectively.

Parameter	Minimum	Maximum	Remark
Operating Frequency Range	24.05 GHz	24.25 GHz	According CEPT/ERC Rec. 70-03
Operating Frequency Range	21.650 GHz	26.650 GHz	
Mean power spectral density (e.i.r.p.)		-41.3dBm/MHz	Averaging time: 50ms
Peak Power (e.i.r.p.)		0 dBm/50MHz	-14dBm/10MHz
Residual Carrier Power		-10dBm	Allocated within 24.05-24.25GHz

Table 1 : Characteristics of SRR 24 GHz systems

3 CONCLUSIONS OF THE COMPATIBILITY STUDIES ACCORDING TO ECC REPORT 23

3.1 Compatibility with FS (Fixed Services)

The long-term compatibility scenario with SRR with 100% percentage of cars equipped with SRR devices in visibility of the FS receiver was studied. Due to the complex sharing scenario, a number of assumptions had to be made. For simplification, the simulations were restricted to two scenarios (1 lane and 4 lanes scenarios) with 2 active forward sensors per car. Important factors such as the FS antenna height and distance from the road (offset), distance between cars and different models for the rain attenuation, which could heavily influence the results of the study were varied in order to be able to compare their effects.

Due to the complexity of the compatibility scenario, a simplified propagation model was chosen. In this model, propagation effects such as spray due to preceding cars, clutter losses (except from other cars) and reflections of SRR transmissions from the road or other cars were not taken into account, since it was uncertain whether or not and to what extent (in dBs) these effects influence the sharing situation.

The results of the studies with all assumptions described above show that the protection criteria of the FS is exceeded by 0 to 20 dB depending on the scenario and on the combination of the factors. Considering that the SRR devices are to be operated on a non-interference basis, it is concluded that SRR deployed in the 24 GHz band operating at a –41.3 dBm/MHz e.i.r.p density are not compatible with FS in the long-term. 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.

In addition, on a short-term basis, it was concluded that an e.i.r.p. mean power density of –41.3 dBm/MHz associated with an e.i.r.p peak limit of 0dBm/50 MHz could be sufficient to protect the FS as far as the percentage of cars equipped with SRR devices in visibility of the FS receiver is limited to less than 10% or less than a few percent depending on whether the protection criteria is to be met in all cases; 10 % is equivalent to a 10 dB decrease of the aggregate power. **Finally, even though the studies have been limited to the 23 and 26 GHz FS bands, the calculation results and conclusions are still valid in the 28 GHz FS band and have also to be taken into account for the 32 GHz band**.

3.2 Compatibility with EESS (Earth Exploration Satellite Services)

Using the assumptions that SRR e.i.r.p. is –41.3 dBm/MHz with a 100% percentage of vehicles equipped with SRR devices in the EESS pixel, lead to the conclusions that SRR cannot share the band with the EESS (passive) in the band 23.6-24 GHz. However, a percentage of vehicles equipped with SRR devices in the EESS pixel lower than 100 % provides a decrease of the aggregate power, e.g. around 10 dB for a percentage limited to 10 %.

3.3 Compatibility with RA (Radio Astronomy)

The sharing study between the SRR application at 24 GHz and the Radio Astronomy Service was done on the assumption of a mean e.i.r.p. per SRR device of –103.3dBm/Hz. Compatibility is not feasible, with a calculated negative margin in the order of 60 dB for spectral line observations and 80 dB for continuum observations, with a device density of 100 devices per km^2 that are transmitting into the direction of the radio astronomy station.

4 REVIEW OF THE ASSUMPTIONS USED IN COMPATIBILITY STUDIES

4.1 Characteristics of SRR systems

4.1.1 Assumptions used in ECC Report 23

The mounting height from 24 GHz SRR is limited to maximum 1.5 m. However, the typical mounting height for forward and rearward facing sensors is bumper height (about 0.5 m for cars).

Due to various impacts of bumpers, mainly metallic paint, a bumper loss of – 3 dB has been considered.

European regulation for SRR 24G imposes that emissions within the 23.6-24 GHz band that appear 30° or greater above the horizontal plane shall be attenuated by at least 25 dB up to 2010 and 30 dB up to 1 July 2013 for SRR 24G systems. Compatibility studies detailed in ECC Report 23 focused on long term deployment scenarios assuming 100% of road vehicles equipped with SRR 24G and considered where relevant an attenuation of 35 dB (as per the FCC rules by January 1, 2014).

It was assumed that a maximum of 4 active sensors per car are representative of a long term situation, two pointing frontward and two backward.

4.1.2 Review

Due to the fact that SRR devices are basically license-exempt devices, it is quite obvious that one basic assumption used in ECC Report 23 consists of a 100% deployment of SRR 24 GHz. The assumption of a full deployment is also particularly justified in a context where the objective is to maximise the reduction of the number of road fatalities in Europe.

For the automotive industry, this assumption may be unreasonable due to development of competitive alternative technologies for some of the functionality supplied by 24 GHz SRR devices and long-term deployment of 79 GHz SRR devices. No automotive technology has demonstrated 100% market penetration under such circumstances and current market trends support that it is unrealistic to assume 24 GHz SRR would reach such deployment.

However, it has to be noted that the assumption of a 100 % deployment is necessary in order for administrations to get a worst case reference analysis, especially in this case where a purely passive band is addressed. Given the potential adverse effects on Radiocommunication Services, it is necessary for administrations to assume that the type of safety systems under consideration could be the most successful technology in long term.

Finally, one can note anyway that, even with a lower market penetration, the compatibility with EESS sensors will not be reached (see section 4.3.2). Therefore possible deviation on the market penetration assumption does not enable to challenge the overall conclusion regarding the use of SRR 24 GHz.

4.2 Compatibility with FS (Fixed Services)

4.2.1 Assumptions used in the FS studies

The main assumptions used in ECC Report 23 for the compatibility with FS (Fixed Service) are given in the table below:

Category	Description	Comment
Frequency bands	23 GHz band (22-23.6 GHz) 26 GHz band (24.5-26.5 GHz) 28 (27.5 – 29.5GHz) 32GHz (31.8 – 33.4GHz)	ECC Report 23 states that “Even though the studies have been limited to the 23 and 26 GHz FS bands, the calculation results and conclusions are still valid in the 28 GHz FS band and have also to be taken into account for the 32 GHz band”
Victim station characteristics	Noise Factor = 6 dB Minimum feeder loss = 0 dB P-P antenna gain = 41 dBi FWA sectorial antenna gain = 18 dBi	
Interference scenario	Aggregate interference of short range radar along a main road parallel to FS link	Coexistence with FS is constrained by aggregate interference scenario and associated long-term protection criteria. Short term interference study is also presented in ECC Report 23
Protection criteria used in study	$I/N = -20$ dB, based on ITU-R Rec. F.1094 and P.530 and assuming 0.5% apportionment for SRR	
Main assumptions used in study	Number of road lanes: 1 and 4 Rain attenuation: 0.6 dB/km and 3 dB/km FS antenna height: 10 m, 18 m and 25 m FS antenna offset: 10 m and 30 m Distance between cars: 20 m, 50 m, 100 m and 150 m	Several additional parameters for interference calculations were discussed such as the number of active SRR device per car, SRR antenna pattern, bumper loss, SRR sensor height, rain correlation and water spray attenuation, car shielding, clutter loss, reflection/diffraction from surrounding vehicles, polarization decoupling and gating…

Table 2 : Main assumptions used in the compatibility studies with the Fixed Service (FS)

4.2.2 Review

Studies in ITU-R Task Group 1/8 have considered two deployment scenarios recognising the difference in deployment practices at regional level in CEPT and other administrations from Region 2 (See section 1.5 of Annex 2 to ITU-R Report SM.2057).. The studies derive different numerical conclusions based on two different FS deployment cases with the assumptions described below. Deployment Case 1 reflects the European situation and is based on studies in ECC Report 23 which were submitted to TG1/8 and Deployment case 2 represents studies from one administration from Region 2. The following information is taken from the ITU-R Report SM.2057:

FS Deployment Case 1: may be appropriate for countries where the deployment of PP links, with low FS receiver antenna height, is frequent along high traffic density roads, and extensive use of these bands for FS links in mobile network infrastructure may occur. An average SRR e.i.r.p. emission limit of at least −50 dBm/MHz is necessary; however, where the joint concurrence probability of the more severe deployment situations (i.e. lower FS antenna heights closer to a road) is considered, an e.i.r.p. density limit of −60 dBm/MHz is necessary for long-term coexistence.

FS deployment Case 2: may be appropriate for countries, where less stringent infrastructural requirements regarding the FS receiver height and distance to the road might prevail. The SRR e.i.r.p. emission limit of −41.3 dBm/MHz may be considered appropriate, when other mitigation factors (unpredictable but possibly present) are taken into account. However, this higher e.i.r.p. density power increases the risk of interference from SRR to the FS in case those mitigation factors might not be present in full.

Two frontward radars from a car driving towards the FS antenna are considered, while their positioning will be:
- For the FS Deployment Case 1, the 4 devices are placed at the car profile corners.
- For the FS Deployment Case 2, the 2 front devices are placed 20 cm inside from the car profile.

Attenuation due to rain in the FS link path is considered.
- For the FS Deployment Case 1, taking into account also low rain rate zones, rain correlated attenuation of 0.6 dB/km will be used; a value of 3 dB/km would also be used for comparison.
- For the FS Deployment Case 2 an average of 2 dB/km will be used, still evaluating the variation with the maximum of 3 dB/km.

Additional attenuation due to water spray caused by preceding vehicles has also been evaluated.
- Not taken into account for the FS Deployment Case 1 case.
- For FS Deployment Case 2 a spray attenuation of 3 dB is considered as a conservative assumption.

When vehicles, queuing on roads, come closer, the preceding vehicle acts as shielding towards the FS victim antenna.
- For the FS Deployment Case 1, the shielding model for the elevation plane and Line of Sight on-off function for the azimuth plane.
- For the FS Deployment Case 2, the shielding model of the elevation plane is also used for the azimuth plane.

Clutter loss due to shielding by objects such as traffic signs, bridges, trees, guardrails, buildings etc. is been taken into account. The assumptions for the two study cases will be:
- For the FS Deployment Case 1 no clutter losses are considered.
- For the FS Deployment Case 2 an average clutter loss of 7 dB has been assumed.

H or V or even slant polarization are possible.
- No polarisation decoupling for the FS Deployment Case 1.
- 3 dB mitigation for the FS Deployment Case 2.

A number of other factors might reduce the aggregated interference potential through a reduced average number of devices active in the same time or frequency domain. This results in an activity factor for the 24 GHz SRR devices.
- No additional reduction by the 24 GHz SRR activity factor for the FS Deployment Case 1.
- 7 dB additional activity factor mitigation for the FS Deployment Case 2.

For the FS Deployment Case 2, an additional 3 dB more margin was considered by attributing an apportionment of 1% (given in ITU-R Recommendation F.1094 for all secondary and unwanted emissions) completely to the 24 GHz short range radar systems.

In the conclusions of ITU-R Recommendation SM.1757, Study 1, which concludes to incompatibility, is presented as being appropriate for countries where the deployment of P-P links with low FS receiver antenna height is frequently located along high traffic density roads combined with extensive use of these bands by FS links in mobile network infrastructure.

Conversely, Study 2, showing that coexistence would be feasible under certain conditions, is appropriate for countries, where less stringent infrastructural requirements regarding the FS receiver height and distance to the road might exist.

In addition to these ITU TG 1/8 considerations SARA notes that, based on extensive compatibility discussions in Japan, it had identified additional assumptions that should be taken into account, e.g., current car configuration of forward looking sensors is typically at least 20 cm inside from the corners; while attenuation due to water spray is difficult to measure, water directly on the bumper is more easily determined to cause additional damping and; current SRR manufacturers use different polarizations.

Finally, it should be observed that careful assessment in a European context of the various elements presented above, and of their impact on compatibility studies detailed in ECC Report 23, would require detailed consideration. If appropriate, such investigation should be conducted within Working Group Spectrum Engineering (WGSE) of CEPT/ECC.

4.3 Compatibility with EESS (Earth Exploration Satellite Services)

4.3.1 Assumptions used in the EESS studies

The main assumptions used in ECC Report 23 for the compatibility with EESS (Earth Exploration Satellite Services) are given in the table below:

Category	**Description**	**Comment**
Frequency bands	23.6-24 GHz	RR No. 5.340 applies to frequency band 23.6-24 GHz
Victim station characteristics	EESS antenna gain = 45 dBi (Push-Broom sensor) and 36 dBi (AMSU-A sensor)	
Interference scenario	Aggregate interference of randomly distributed short range radar systems deployed within an EESS pixel	Coexistence with EESS is constrained by aggregate interference calculations on Cross-track nadir EESS sensors. Interference calculations on conically scanned EESS instruments are also presented in ECC Report 23.
Protection criteria used in study	EESS interference threshold = −166 dBW in a reference bandwidth of 200 MHz, based on ITU-R Rec. SA 1029-2	Maximum interference level from all sources. Such threshold corresponds to a measurement sensitivity of 0.05 K. The number of measurement cells where the interference threshold can be exceeded must not be more than 0.01% of pixels in all service areas for any kind of instrument.
Main assumptions used in study	Attenuation for emissions that appear 30° or greater above the horizontal plane = 35 dB (as per the FCC rules by January 1, 2014) Density of vehicles = 123 vehicles/km2 (highway scenario) and 330 vehicles/km2 (urban/suburban areas).	Several additional parameters for interference calculations were discussed such as the number of active SRR device per car, bumper loss, polarization decoupling, gating, scattering effect, atmospherical loss (ITU-R P.676)…

Table 3 : Main assumptions used in the compatibility studies with EESS (Earth Exploration Satellite Services)

4.3.2 Review

As far as EESS is concerned, the current maximum 7% market penetration as currently specified in Article 5 of Commission Decision 2005/50/EC was based on technical information available at that time and given in Decision ECC/DEC/(04)/10, consistently with ECC Report 23, i.e. directly translating the negative margin produced by a 100% SRR penetration compared to the EESS protection criteria in SRR market penetration to allow compatibility (7% being equivalent to a 11.5 dB negative margin).

Since the adoption of these ECC and EC Decisions, the SRR 24 GHz issue was further studied in ITU-R TG 1/8 that considered more detailed and up-to-date assumptions and analysis. The TG 1/8 summary and conclusions are 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 the analysis, data derived from measurements performed in the band 23.6-24 GHz, where vehicular radars are in operation, will be corrupted in corresponding EESS observations (cities, roads or motorways).*

Car density per km²	**Resulting margin with 5% apportionment**	**Resulting margin with 1% apportionment**
123 (highway scenario)	−22.3	−29.3
330 (suburban scenario)	−26.5	−33.5
453 (urban scenario)	−27.9	−34.9

Table 4 : Summary of interference analysis between 24 GHz SRR and EESS sensors

> *This study accounts for mitigation techniques such as improved SRR antenna side lobes above 30° of the horizontal plane (35 dB attenuation by 2014 in the US rules) as well as four active SRR per car over the eight SRR implemented.*
> *It has to be noted that other aspects were not considered in the interference analysis. Some elements such as operation modes or market penetration could decrease the negative margin whereas other elements such second reflection effects and future developments of EESS sensors could further degrade these margins. These factors are expected to offset each other to a significant degree.*
> *Considering the current level of negative margin, it appears unlikely that, at 100% deployment, other possible mitigation techniques could provide efficiency in achieving the protection to EESS from the 24 GHz SRR.*

It can also be stressed that the situation related to the US administration was expressed in a specific note as follows and recognising that their domestic rules were based on a previous analysis and highlighting a number of short-comings:

> *"It has to be noted that one Administration has already established its domestic rules allowing vehicular anti-collision short range radars (SRR) to operate in the 23.6 to 24.0 GHz, based on a previous analysis using different parameters and assumptions.*"*

* • *Scattering or reflection of SRR signals was not used in this analysis. Later studies, as described in Section A6.1.5.5.2, found that scattered energy added to the direct energy could substantially increase the total energy directed toward the sensor.*

• *The interference threshold used in this administration's analysis was based on Recommendation ITU-R SA.1029-1 which contains an interference threshold value for sensors in this band that is 6 dB higher than the corresponding value in the current Recommendation ITU-R SA.1029.*

• *This analysis apportions 100% of this interference threshold to the UWB SRR devices. A 1% apportionment would decrease the margins by 20 dB.*

On the same principle as in Decision ECC/DEC/(04)10, the 35 dB negative margin as given in the TG 1/8 conclusions translates into a maximum SRR 24 GHz penetration of 0.031% to ensure protection of EESS passive sensors, far from the current 7% criteria based on ECC Report 23.

It is hence obvious that, should it be a review of ECC Report 23 conclusions and subsequent provisions of Decision ECC/DEC/(04)10, this would lead to a tightening of the conditions under which SRR 24 GHz could be authorised to operate over the 23.6-24 GHz band. Strictly speaking, this should be transferred into a cut-off date at the shortest notice, without waiting for 1st July 2013.

Although arguing about the current delay in SRR deployment or about the non-reasonable nature of a 100% SRR 24GHz penetration, it is also obvious that these elements would in any case never allow to ensuring a compatibility situation between SRR 24GHz and EESS sensors.

The ECC and EC Decisions being a compromise and accepted as such, the EESS community did not try to make use of the TG 1/8 conclusions to request a review of these decisions, but these conclusions leading to a 0.031% maximum SRR penetration gives a strong justification to maintain *"à tout prix"* the 1st July 2013 cut-off date, irrespective of the current and expected low SRR deployment reported by SARA.

As a conclusion for the 23.6-24 GHz band and the EESS case, it appears clearly that there is no room for substantial change of status of SRR 24 GHz and related provisions.

4.4 Compatibility with RAS (Radio Astronomy)

4.4.1 Assumptions used in the RAS studies

The main assumptions used in ECC Report 23 for the compatibility with RAS (Radio Astronomy) are given in the table below:

Category	Description	Comment
Frequency bands	22.01-22.21 GHz 22.21-22.50 GHz 22.81-22.86 GHz 23.07-23.12 GHz 23.60-24.00 GHz	RR No. 5.340 applies to frequency band 23.6-24 GHz RR No. 5.149 applies to the other listed frequency bands
Victim station characteristics	Radio astronomy antenna gain = 0 dBi	Corresponds to sidelobes RAS antenna gain at 0° elevation.
Interference scenario	Aggregate interference of randomly distributed short range radar systems deployed around a Radio Astronomy station.	Methodology given in ERC Report 26. Relies on clear-air propagation models given in Recommendation ITU-R P.452. This involves several propagation mechanisms: Line-of-Sight propagation; spherical-earth diffraction and tropospheric scatter.
Protection criteria used in study	Maximum permissible spectral power flux density = -215 dB($Wm^{-2}Hz^{-1}$) for spectral line observations and -233 dB($Wm^{-2}Hz^{-1}$) for continuum observations, based on ITU-R RA.769. Fraction of data-loss due to interference = 2%, based on ITU-R RA.1513.	
Main assumptions used in study	Maximum tolerable e.i.r.p. at a frequency of ~22 GHz per SRR device operating at 24 GHz is calculated as a function of SRR density in order not to exceed the protection criteria for radio astronomy for spectral line observations. Calculation results are directly extrapolated for continuum observations (broadband) in the frequency band 23.6 – 24 GHz.	Various parameters used in the interference calculations e.g. SRR sensor height, radio astronomy antenna height, minimum separation distance, maximum distance for calculations…

Table 5 : main assumptions used in the compatibility studies with RAS (Radio Astronomy)

4.4.2 Review

If all possible mitigation factors can be applied, including sufficiently large exclusion zones around radio astronomy antennas, then sharing between automotive SRR at ~24 GHz and radio astronomy could be possible. Site specific studies have indicated exclusion zone radii of 1 to 35 km for a uniform density of 100 SRR devices per km^2 from which emission is received by a radio telescope. These site specific radii for the protection zones are quite different and may be review.

The definition of exclusion zones was under the responsibility of national administration. The potential benefits that could result from their reconsideration should be assessed prior to possibly revisiting their definition.

In addition, it should be observed that, in accordance with Decide 5 of Decision ECC/DEC/(04)10, automatic deactivation is not required for SRR 24GHz systems transmitting in the band 23.6 - 24 GHz with an e.i.r.p. lower than -74 dBm/MHz.

The representative from the Radio Astronomy (CRAF) also expressed that co-existence between Radio Astronomy (SERVICE) and SRR 24GHz (APPLICATION) is not feasible, since more than 60-80dB are missing for such co-existence based on ECC Report 23, and questioned the enforceability of possible mitigation solutions like "sufficiently large exclusion zones around radio astronomy antennas". In practical terms, RAS and automotive SRR on 24 GHz co-existence is not possible.
CRAF further referred to the primary status of RAS in the frequency band 23.6-24 GHz, as well as to footnote No. 5.340 of the Radio Regulations which states that '*all emissions are prohibited*', and expressed support for migration of SRR systems to the 79 GHz frequency range.

5 CONCLUSION

No new evidence has been presented so far to suggest that the original assumptions used in both ECC Report 23 and in TG1/8 with respect to FS studies are either in conflict or are no longer valid. It should be noted that these studies were results of extensive discussions where all interested parties were involved and that lead to adoption of EC Decision 2005/50/EC.

According to ITU-R Recommendation SM.1757, the result of interference analysis using specific EESS systems characteristics concludes that a 100% deployment of SRR operating at 24 GHz results in potential interference exceeding the EESS threshold up to 35 dB (i.e. a maximum 0.031% penetration of SRR). In addition to that, ITU-R Report 2057 stipulates that considering the current level of negative margin, it appears unlikely that, at 100% deployment, other possible mitigation techniques could provide efficiency in achieving the protection to EESS in the passive band from the 24 GHz SRR.

As a conclusion for the 23.6-24 GHz band and the EESS case, it appears clearly that there is no room for substantial change of status of SRR 24 GHz and related provisions.

In the absence of mitigation factors adequate to enable the protection of RAS, co-existence is not feasible. The calculated maximum tolerable e.i.r.p. per SRR device at ~24 GHz is several orders of magnitude below the currently considered e.i.r.p. per SRR device of –41.3 dBm/MHz. Only sufficiently large exclusion zones around radio astronomy antennas guarantee sharing between automotive SRR at ~24 GHz and radio astronomy. Such approach is obviously not realistic in the long term.

Finally, simply by taking into account the constraints resulting from coexistence between SRR 24 GHz and EESS, FS & Radio Astronomy, CEPT can conclude that existing regulation for SRR 24GHz systems should in principle be kept without substantial changes.. It should be further noted that ECC Report 23 states “even though the studies on FS have been limited to the 23 and 26 GHz FS bands, the calculation results and conclusions are still valid in the 28 GHz FS band and have also to be taken into account for the 32 GHz band”. CEPT agreed however that further consideration could be given on the status of existing regulation for SRR 24GHz systems with the frame of discussions in response to part 2 of the EC Mandate on SRR (see CEPT Report 37).

In addition to these technical justifications, it has to be recalled that the 23.6-24 GHz band is protected by the footnote No. 5.340 of the Radio Regulations which states that ‘*all emissions are prohibited*’. RSPG opinion developed in October 2006 about the scientific use of radio spectrum mentioned that ‘*In particular, the RSPG urges Member States to respect their obligations under No. 5.340 of the Radio regulations and recommends the EC, when preparing spectrum measures, to support the needs of the scientific services in these particular bands.*‘. Therefore, it would also be consistent to confirm that no new SRR24 GHz systems can be allowed also from a regulatory point of view.

ANNEX 2: REVIEW OF THE DEVELOPMENT OF SRR 79GHZ TECHNOLOGY

1 INTRODUCTION

CEPT identified, within the frame of the first EC Mandate to CEPT on SRR[2], the 79 GHz range (77-81 GHz) as the most suitable band for long-term and permanent development and deployment of short-range radar.

The designation and long-term availability of the 79 GHz frequency range required legal certainty as a clear incitement for manufacturers to develop SRR in the 79 GHz range. It was part of a regulatory package allowing early introduction of SRR applications in Europe in the 24 GHz frequency range (21.65-26.65 GHz) which may be used on a temporary basis with limited number of equipment in the European market and for a limited time frame.

The regulatory package on SRR systems adopted in 2004 called for a general review to take place in 2009. This analysis aims to review the development of 79 GHz technology and to assess more generally the continuing relevance of existing regulation for SRR 79GHz systems.

2 INITIAL DESIGNATION OF PERMANENT FREQUENCY BAND FOR SRR SYSTEMS IN EUROPE

The following is quoted from CEPT Report 3 developed in response to the first EC Mandate to CEPT to harmonise radio spectrum to facilitate a coordinated EU introduction of Automotive Short Range Radar systems and adopted by ECC in July 2004.

> *"Based on the technical requirements on frequency range and power levels described in the System Reference document from ETSI (ETSI TR 102 263), the frequency band 77-81 GHz has been identified by the FM WG as the permanent frequency band for Short Range Radars (SRR).*
>
> *It was noted that the 76-77 GHz band, which is harmonised on a worldwide basis for the Radiolocation Service, is designated in ECC/DEC/(02)01 for Road Transports and Traffic Telematics, more specifically for infrastructure and vehicular radar systems. The 76-77 GHz band is commonly used by Automotive Long Range Radars which are commercially available since 1999 from European vehicle manufacturers. However, it has been indicated by the automotive industry that Short Range Radar systems based on Ultra Wide Band technology are not compatible with Long Range Radars if operating within the same frequency band. Consequently, SRR requires the designation of a new band allowing a 4 GHz bandwidth operation in the 79 GHz range (77-81 GHz).*
>
> *The European Research project Radarnet (IST 14031) started in 2000 and had as objective to study and develop on a pre-competitive basis the realization of a synchronized 77 GHz radar network with improved performance by multilateration techniques between 4 short and one long range radar. Both a new MMIC chipset and advanced signal processing techniques were intended to improve advanced driver assistance functions. A new chipset was not realized due to Infineon leaving of the project.*
>
> *SARA however indicated that 79 GHz technology is not yet available for mass production.*
>
> *The adoption and early implementation of the ECC Decision for the 79 GHz band was seen as critical to provide a clear indication to the automotive industry as well as the component industry that the required frequency bands will be made available on time and on a Europe-wide and permanent basis. A stable and permanent frequency band for SRR equipment is important for the automotive components industry to make the substantial investments necessary for deployment of the 79 GHz frequency band.*
>
> *The FM WG agreed that the frequency band 77-81 GHz should be made available throughout Europe as soon as possible and not later than January 2005. This is included in Decides 4 of the ECC Decision and thus administrations committing to the ECC Decision also commit to an early implementation.*
>
> *The 79 GHz frequency designation should be harmonised within EU member states and other CEPT countries applying the R&TTE Directive and the equipment operating in the 79 GHz band should be agreed as 'class 1' equipment in accordance with the R&TTE Directive and the Commission Decision 2000/299/EC (6.4.2000). It is*

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[2] Mandate to CEPT to harmonise Radio Spectrum to facilitate a coordinated EU Introduction of Automotive Short-Range Radar (SRR) Systems (June 2003)

envisaged that the Radio Spectrum Committee provides the necessary legal certainty to the implementation of the ECC Decision in order to ensure a permanent harmonised solution within EU member states."

Decision ECC/DEC/(04)03 was adopted by the ECC at its meeting 15-19 March 2004 and followed by 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).

The following technical requirements are specified in existing regulation for 79 GHz SRR systems.

Parameter	**Minimum**	**Maximum**	**Remark**
Operating Frequency Range	77 GHz	81 GHz	
Mean power spectral density (e.i.r.p.)		-3 dBm/MHz	The mean power density outside a vehicle resulting from the operation of one SRR equipment shall not exceed -9 dBm/MHz e.i.r.p.
Peak Power (e.i.r.p.)		+55 dBm	

Table 6 : Characteristics of 79 GHz SRR systems

3 REVIEW OF THE DEVELOPMENT OF 79 GHZ SRR SYSTEMS

3.1 Research and Development

3.1.1 Information from KOKON and RoCC projects

The following information was provided by SARA and originally submitted to RSC meeting in July 2008 (see Doc. RSCOM08-51):

The KOKON project was the first step towards development of 79 GHz technology and ran until the end of August 2007. A successor German national funded project, named RoCC (Radar on Chips for Cars), will focus on commercialization of 79 GHz technology, starting in September 2008 and expected to run for three years – early background on RoCC is attached. The goals of the project, broadly stated, are the following:

- Radar on Chip (scalable universally usable radar transceiver for Short, Mid and Long Range)
- Automobile radar technology in the 76-81 GHz frequency range; especially also SRR in the 77-81 GHz range for affordable costs
- Continuation of the development of SiGe semiconductor process technology and MMICs (500 GHz cut-off-frequency, higher integration, reduction of power consumption, better S/N sensitivity)
- Investigations of car integration (bumper, paintings, etc.) and integrated antenna for low cost SRR
- Semiconductor packaging (feasibility only)

As an indication of issues under study, one SARA member active in the bumper technology sector informed the group of its work with materials and paints to improve radar transparency at 79 GHz. Current testing with conducting and non-conducting materials indicate that 1-2 years of experimental testing will be required to prove applicability for series production. This information indicates that in addition to sensor technology also bumper materials and paints must be developed as part of RoCC.

An overview over the RoCC project is given in the attachment. SARA has noted that the project also involves benchmarking of sensors and it is scheduled to run until 31 August 2011.

SARA has highlighted that the timeline for development and implementation of 79 GHz SRR is important. There are several critical phases to this timeline. Following basic research done by KOKON and RoCC, sensors suitable for mass production must be developed and bumper materials and painting issues must be solved. After this phase, the sensors must be integrated into the overall vehicle design. The overall system performance also must be verified using standard manufacturer techniques. Because this application is tied to road safety, manufacturers would normally conduct actual road condition tests up to 1 million km on the road. 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.

3.1.2 Information from RADAR ACC and ARPOD Projects

The following information was provided by PSA Peugeot Citroën Automobiles.

The RADAR ACC and ARPOD projects financed by the general delegation of the French equipment (DGE) in complement to internal PSA Peugeot Citroën Automobile works are described further in this annex 2.

The RADAR ACC Project, started on 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 UWB technology and materials bumper adapted.

The target of these projects is twice:

1. to have at the earliest a technology based on 76 GHz SiGe (already marketed) at a lower cost in comparison with today,
2. to use solely a single multi sensor mode covering both the Long Range (76 GHz) and the Shorts Range (79 GHz UWB) contrary to the competitive solutions combining two families of radars: one Long Range (76 GHz) and two Shorts Range 24 GHz UWB (the first located to the right of bumper of the vehicle and the second located to the left of bumper of the vehicle),
3. to validate this technology in term of functional and of integration.

The major results of the RADAR ACC Project are:

1. obtaining of a prototype sensor allowing to cover all benefits correctly thanks to an use of technology radar with a multi sensor mode covering both the Long Range (76 GHz) and the Shorts Range (79 GHz UWB),
2. specification for a production of a radar including a system of multi mode antenna at a lower cost.

The major results of the ARPOD Project are:

1. specification of material bumper, with compatible paintings and their industrial process,
2. development of an architecture allowing the fusion of the 76 GHz and the 79 GHz UWB sensors in solely a single sensor,
3. manufacturing of radars sensors whose performance will be independent of the paintings typologies used for the bumper.

The advantages of the 76 GHz / 79 GHz UWB technologies developed in the RADAR ACC and the ARPOD Projects are:

1. a synergy of the development of the both technologies contrary to the couple 24 GHz Narrow Band (NB) and 24 GHz UWB,
2. the benefit of the same peak power contrary to the couple 24 GHz Narrow Band (NB) and 24 GHz UWB,
3. the easiness of the installation of a single radar sensor instead of three radars sensors,
4. the global costs and services during the diagnosis of the breakdowns and the repairs of the bumper in the case of one installation of a system of three radars sensors in the facade (one Long Range Radar 76 GHz and two Short Range Radar 24 GHz UWB) harmful for the final customer.

3.2 Cost and availability

Affordable technology at low cost is a precondition for technical implementation of SRR technology. SRR based automotive applications are ordered by the customer only at an affordable price. Pricing is therefore the critical aspect of SRR technology in general.

24 GHz SRR radars today can be produced using standard surface-mount production lines and semiconductors packaged in ceramic or low-cost plastic packages. Power consumption is moderate and therefore heat removal is viable.

By contrast, 76-81 GHz MMICs today are available as “bare-die” units only, requiring sophisticated “chip-on-board” assembly. Power consumption is high, which requires relatively expensive precautions for heat removal. As mentioned above both issues (lower power consumption and low cost packaging) are being addressed in the RoCC project as a part of ongoing sensor product development. Pre-qualified plastic packaging for 79 GHz (such as “embedded wafer-level ball grid array” - eWLB) should be available by end of 2010 as well as MMICs with reduced power consumption.

In spring 2009 competitive 77 GHz SiGe-based long range radar will be available on the market as a basic sensor for a bundle of functions. The building blocks of the chipset used in this radar architecture will be suitable also for the frequency range of 79 GHz SRR. Thus, availability of suitable chipsets is no longer an issue (there are at least 3 semiconductor suppliers). Nevertheless, development of low cost chip assembly techniques for standard SMD (Surface Mounted Devices) production lines must be accomplished.
.
79 GHz SRR will be adopted most readily if there are economies of scale and widespread consumer familiarity with radar based vehicle applications. If industry is required to restrict use of SRR applications during the period that 79 GHz technology is being developed, its acceptance in the market and thus effect on safety related goals will be seriously impeded once it becomes available. Moreover, if there is a “technology gap” between the time 24 GHz SRR can be used and when 79 GHz is ready for deployment, there is a risk that manufacturers will defer using radar for a very long time.

Today the 77 GHz LRR is already fully qualified, installed in vehicles and in use on the roads worldwide. The 79 GHz semiconductor technology can be derived from the 76 GHz semiconductor technology. Some companies have developed the chip sets based on SiGe technology for the safety automotive applications. During the public consultation of this Report, it was observed by one respondent that prototypes of the 79 GHz UWB SRR modules are actually available today and that fully qualified modules are planned to be available in 2012/13 within RADAR ACC and ARPOD projects.

3.3 Applications

Based on the success in road safety of 24 GHz SRR shown in today’s collision mitigation systems the clear evidence of safety benefit of SRR especially under adverse condition is proven.

24 GHz technology has been the first step to observe objects in the vicinity of a car, thus enabling object detection for applications of automotive safety. Today this technology is available at an affordable price.

The European frequency regulation for 24 GHz automotive radar is based on a frequency shift to 79 GHz technology in 2013. Today 79 GHz technology is not yet mature to make this step in time. Nevertheless several companies are working intensively on the development of this technology to fulfil the European regulation but also because there are important technology advantages to further improvement of SRR sensor performance.

79 GHz technology follows the general trend to higher frequencies in wireless communication and sensing applications allowing enhanced performance. Ongoing technology development has already demonstrated that 79 GHz technology promises technical advantages in some important aspects for automotive applications:

- Improved angular resolution: For a given aperture, the angular resolution increases with frequency. As angular resolution depends on the ratio of wavelength to antenna aperture it improves at a given aperture almost by a factor of 3 compared to 24 GHz systems. Improved angular resolution allows a better separation of objects, improved object tracking, and interpretation of complex traffic situations (pedestrian, cyclists, stationary objects, cars, and trucks).
- Smaller sensor size: For a given angular resolution, a 79 GHz sensor can be considerably smaller compared to a 24 GHz sensor, allowing for a better integration into the car.
- Improved speed information: Doppler resolution of object distance is RF frequency dependent. Higher RF frequency results in better Doppler resolution
- Higher range: 24 GHz systems are limited in range by the frequency regulations that provide that the effective isotropic radiated power (e.i.r.p.) may not exceed -41.3dBm / MHz in average. For 79 GHz, more output power is allowed, leading to a better range compared to 24 GHz sensors.

The increased sensor performance with 79 GHz technology should allow a more precise object detection. In consequence vehicle applications will be improved for predictive safety functions. Moreover, 79 GHz technology will also allow one common technology platform with the 77 GHz technology used for Adaptive Cruise Control (ACC) in the 76-77 GHz frequency range.

With respect to comparative element with alternative technologies, SARA does not believe other technologies can “replicate” the operational functions of 24 GHz UWB SRR or 79 GHz UWB SRR. Numerous other technologies can be used to achieve some subset of the applications that these SRR technologies provide, and numerous other technologies may be used in conjunction with SRR. Just as seat belts provide one function while air bags serve another, many of these technologies may complement the goal of active safety. The automotive industry is seeking the best combination of different technologies to achieve accident free driving.

Possible technologies that serve active safety applications and in some cases complement SRR object detection include:

- Ultra Sonic sensors used for parking applications
- Long range radar used for adaptive cruise control (ACC)
- Short range radar, divided into two categories:
  - Ultra-wideband (UWB) – the range of possible applications is greatest with UWB due to the high local resolution and high distance resolution. These applications include object discrimination and object tracking. Examples of vehicle applications on the road today using UWB are collision warning, intelligent brake assistance, pre-crash applications like seat belt pre-tensioner, air cushions closing roofs and windows before a crash might occur, and blind spot monitoring. Contrary to some assertions, the main value of UWB is not for parking aid, but instead for safety applications that require high resolution e.g., object discrimination (separate objects being closely together, object tracking (path of driving to assessed if crossing own path, detection of object corners to get an estimation of size and mass of an object for adaptation of passive safety measures like airbag thresholds).
  - Narrowband (NB) – the distance resolution of this technology limits the performance of applications it can achieve. Narrowband is defined as operating within the ISM-band 24.05 to 24.25 GHz – some systems recently have been discussed using a bandwidth of about 500 – 900 MHz, which is not narrowband. Today's NB applications are blind spot monitoring and lane change assistance. More sophisticated applications will need more bandwidth leading to UWB. For some applications the limited local resolution of narrow band radars is sufficient (Because of police radar in UK and France the bandwidth is limited to 100 MHz). But most of the safety relevant applicants need bandwidths which are classified as UWB.
- Optical technologies:
  - Optical technologies, such as LIDAR (for light detection and ranging) are limited because of the limited availability of the sensor signals under bad weather conditions. These technologies are mostly used for comfort systems such as ACC. For safety applications the car manufacturers use radar. At present only one car manufacturer is known using a laser pulse technology for a safety application but because of its performance only under low speed conditions.[3]
  - Camera technologies have the same limitations of other optical technologies. Cameras will be used widespread in automotive applications, such as traffic sign recognition, lane departure warning, night vision. They will be also used in addition to radar sensors to improve object classification used e.g. for pedestrian protection.
- ITS car-to-car and car-to-infrastructure communication.

  Vehicle safety applications are developed to gain time for reaction and prepare a vehicle in a possible event of a crash. Historically these applications started with passive safety technologies such as seat belts and airbags. The next technology step is the observation of the car itself used in ESP/ESC (Electronic Stability Program / Control), followed by observation of objects surrounding the car (e.g. automotive radar for comfort functions such as ACC leading to safety functions such as collision warning and mitigation). Communication is again one more step to increase the information horizon by using other cars or infrastructure as "sensors". Compared to passive safety the next steps are used to gain more time to react before a crash might occur, but have an even longer time frame than current SRR and in any event will still depend on sensors for object detection.

[3] For instance, one recent market introduction of a Lidar technology is functional at speeds up to 30 km/h for a distance of 8 meters (not 15, as was mistakenly represented in RSCom #26 Item 8). While this is a very important technology, it is not applicable to motorway speeds where a substantial number of accidents occur, does not function well in bad weather and is a complement to the functionalities of UWB technology.

These technology steps are building a hierarchy using the earlier steps as their basis. None of these technologies can be replaced by the other one. They work together and the automotive industry experience with each step leads to further refinements and better applications.

SRR 24 GHz technology was the first step to detect objects in the vicinity of a car in order to enable applications of automotive active safety. There is objective evidence of its impact on accident mitigation.

3.4 Regulation outside Europe

A very important issue is worldwide harmonization of the frequency allocation for 79 GHz (77-81 GHz) as a precondition for successful market development. Currently only Europe and Singapore have allocated the 77-81 GHz frequency range for automotive applications. In Japan SARA will initiate the 79 GHz approval process after finalizing the Japanese compatibility study for the frequency range 22-29 GHz (expected for March 2009). Also in 2009 SARA intends to initiate the 79 GHz frequency regulation process in the US.

4 CONCLUSION

Today's SRR sensor technology uses SRR operating at 24 GHz giving for the first time the opportunity to develop vehicle applications for object detection in the vicinity of a car, making a new generation of automotive safety systems possible.

Future safety and comfort applications for vehicles will benefit from higher sensor performance at smaller size. Pushed by significant progress in Silicon based MMIC technologies and low cost packaging capabilities 79 GHz short range radar is in the process of becoming cost-competitive and affordable. It is recognized that the 79 GHz solution is a long-lasting solution for all vehicle manufacturers to improve active safety devices.

The European frequency regulation currently requires SRR to migrate from 24 GHz to 79 GHz spectrum in the year 2013. The system integration and validation of 79 GHz technology may not be possible in time for a seamless transition. According to SARA, a phase of car integration and extensive car tests will require additional several years in order to ensure that all safety aspects are correctly implemented. The technology to be used in a car line must be fixed several years before start of production (SOP). For instance, car lines with SOP in 2013 were fixed in 2008. Thus, sensors must be mature now to be integrated into car production lines by 2013. During the public consultation of this report, it was however 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 respondent car manufacturer. According to this respondent, this validation will be ended before the deadline of the 1st July, 2013 and this technology will be marketed extensively in the line of product of the car manufacturer from 2014/2015.

Not all car manufacturers who sell products in Europe have plans to include 79 GHz SRR products into their production lines before 2013. One radar manufacturer has stated that 76 GHz products are in use by several European car manufacturers today and 79 GHz products are almost identical. This radar manufacturer expects to have certified modules and sensors for the 79GHz band available around 2012-13. SARA underlined that the car manufacturers need sufficient time for vehicle integration including development of bumper materials and paintings as well as extensive tests for safety applications.
The net result is that independent of the availability of these radar technologies at 79 GHz today, there is a possibility that there may be a gap in the availability of SRR in new cars being placed on the European market after the 24GHz band is no longer available for use in 2013. During the public consultation of this report, it was however observed by one respondent that the problems associated with paints will be resolved before the deadline of the 1st July, 2013.

It is also important for the 79 GHz SRR market growth that availability of a worldwide harmonised frequency allocation is possible. Europe should encourage other markets such as North America and Japan to adopt the same band as the European allocation. In this case Economies of scale would bring costs down, which in turn should expand opportunities for 79 GHz SRR becoming an affordable technology as a mid- and long term solution worldwide with the broad benefits for road safety in Europe that this will bring.

Attachment to Annex 2 on SRR 79G

A) Overview of the RoCC Project (Radar on Chip for Cars)

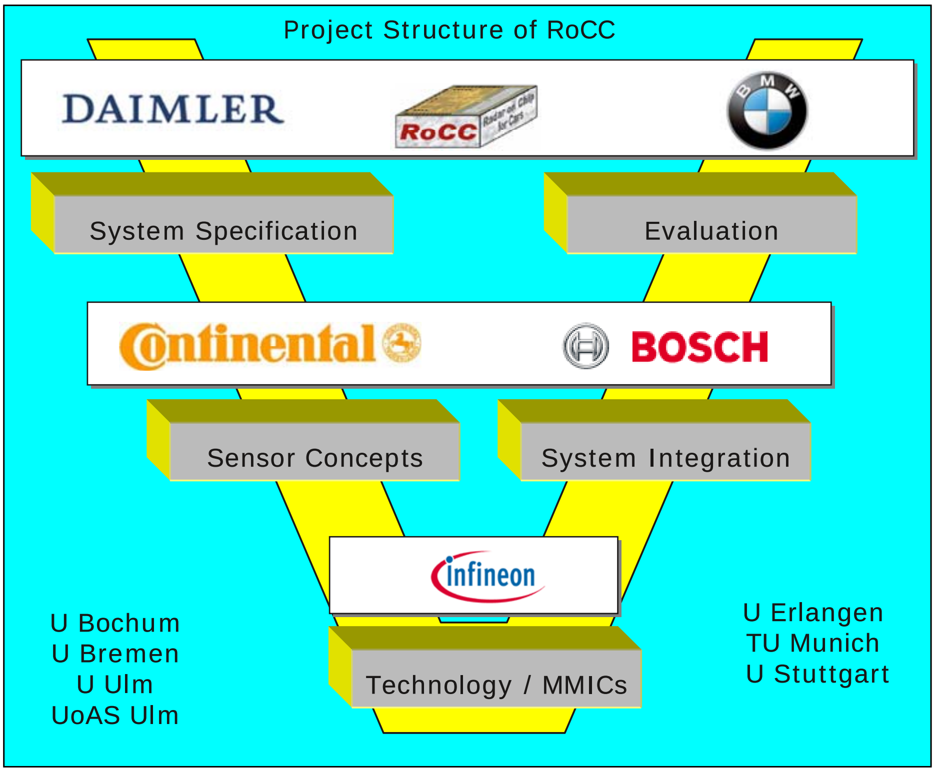
INTRODUCTION

RoCC is the follow-up project of KOKON (1/10/2004 -30/9/2007). Like KOKON it is a German national funded project sponsored by the BMBF (Federal Ministry of Education and Research). The RoCC consortium spans almost the complete automotive supply chain from component manufacturer (Infineon) to Tier 1 suppliers (Bosch, Continental) to OEMs (BMW, Daimler).

Most of these companies have already collaborated very successfully within the KOKON project. The KOKON project was able to demonstrate for the first time the feasibility of low-cost silicon-based radar technology in the 76-81 GHz band. Commercialization of the results of the KOKON project has begun already. In 2008, Infineon introduced its first SiGe radar chipset (RASIC ™) to the open market comprising a single-chip 4-channel radar transceiver for 76-77 GHz advanced ACC applications together with a 19 GHz reference oscillator. Robert Bosch GmbH utilizes these chips for its new LRR3 automotive radar system (3rd generation Long-Range-Radar) which will be launched in early 2009. It is world-wide the first automotive radar sensor in that frequency range using only silicon semiconductors (See Press Release IFX 1/12/2008). A first 79 GHz SRR prototype system based on the same SiGe building blocks has been successfully demonstrated by Continental.

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.

PROJECT ORGANISATION



RoCC is led by Infineon as project coordinator. It started on 1 September 2008, and will run until August 31, 2011. Five work packages comprise the organisational frame work of the project, each led by one of the main partners:

- System Specifications: Daimler (with contributions from BMW, Bosch, Conti)
- Sensor Concept: Conti (with contributions from BMW, Bosch, Infineon)
- Technology and MMICs: Infineon (with contributions from Bosch, Conti)
- Sensor Integration: Bosch (with contributions from Conti)
- System Evaluation: BMW (with contributions from Daimler, Bosch, Conti)

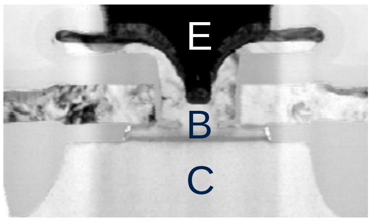
The industrial partners are supported by the following sub-contracted Universities which will contribute with their excellent competencies in the field radar systems, antenna design or millimeter wave circuit design:

- University of Bochum
- University of Bremen
- University of Erlangen-Nuremberg
- University of Stuttgart
- University of Ulm
- University of Applied Sciences Ulm
- Technical University of Munich.

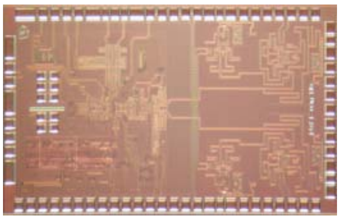
PROJECT GOALS

The main technical, scientific and socio-political goals of the RoCC project are:

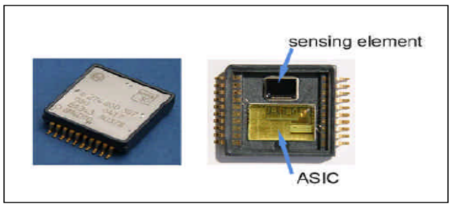
- Affordable vehicle and road safety for everyone
- Strengthening technological leadership in automotive high frequency products and processes
- Development of a cost-competitive radar sensor technology in the 76-81 GHz range with special emphasis to 79 GHz SRR
- Foundation of a sound technology base for migration from 24 GHz SRR to 79 GHz SRR
- Development of highly integrated universally applicable radar MMIC demonstrators
- Improvement of energy efficiency of SiGe-MMICs
- Demonstration of Radar sensors with superior S/N
- Adaptive (smart) sensors from Short Range to Long Range
- Pave way to SMD-Package for SiGe MMICs at 76-81 GHz
- Benchmarking versus 24 GHz solutions
- Demonstrate feasibility of 500 GHz SiGe Technology for automotive radar applications



Automotive 500 GHz SiGe



Highly integrated MMICs



Low cost sensors / systems

B) Overview of the RADAR ACC Project

INTRODUCTION

The RADAR ACC project is complementary to the “Short Range Radar” Project which objective is to offer low cost sensors operating in the frequency band 77 - 81 GHz (79 GHz UWB) for closer safety applications. Compared to the “Short Range Radar” Project, the technologies developed in the RADAR ACC Project are totally different from those existing of the Long Range Radars. The objective of this project is focused at the same time in developing a sensor capable of answering the specifications of the ACC, the pre-crash and the collision mitigation with the association of the 76 GHz / 79 GHz UWB technology. The purpose is to have as soon as possible a technology based on 76 GHz SiGe (already marketed) targeted to 79 GHz UWB at a lower cost and validated in functional and integration term.

An illustration of the advantages of the sensor that must be capable of answering the objective of RADAR ACC Project is given below.

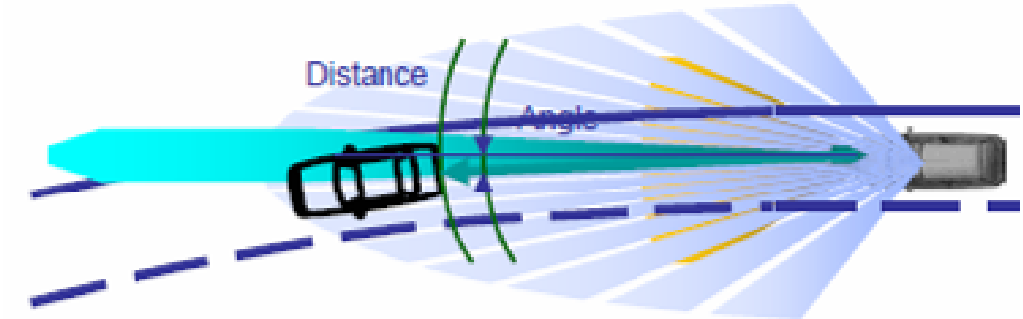


Fig. 1: Illustration of the advantages of the sensor developed in the RADAR ACC Project

PROJECT ORGANISATION

ARPOD project is led by Autocruise (a TRW Company) as project coordinator. It started on January 2007 and will run in the year of 2010. Eight work packages comprise the organisational frame work of the project, each led by one of the main partners:

1. Management: Autocruise
2. Technical specification: PSA, Autocruise
3. Architecture systems: all partners
4. Development of an antenna: ANTENNESSA, IETR, Autocruise
5. Development of an hyper frequency module: Autocruise, ENST-Bretagne, AMG Microwave
6. Development of the signal processing: ENST-Bretagne, AMG Microwave
7. Sensor Integration in the vehicle: all partners
8. Validation in a vehicle: Autocruise, PSA

PROJECT GOALS

The main technical, scientific and socio-political goals of the RADAR ACC Project are:

1. Develop the future generations of radar ACC (covering both applications for Short Range operating in the frequency band 76 – 81 GHz and applications for Long Range operating in the frequency band 76 – 77 GHz) allowing:
    a. to detect the fixed targets,
    b. to discriminate targets in velocity, distance and angle
    c. to have a range of 200 m with applications such as Stop and Go or Follow to Stop.
2. Define and validate the whole radar sub system (antennas, hyper frequencies functions, signal processing),
3. Propose an innovative antenna concept (Short Range and Long Range) to be integrated into the fourth generation (4G) of radars devices,
4. Realize a radar high-frequency head which insures the emission and receiver of the prototype
5. Proceed to the realization of a physical prototype in order to realize the tests in a laboratory
6. Proceed to the tests of validation and to the characterization of the performances of the prototype on vehicle.

C) Overview of the ARPOD Project

INTRODUCTION

An effective reply to the European and Worldwide concerns in improving the road safety consists:

1. to install progressive safety systems following the response time of the driver in order to limit the effects of an accident,
2. to propose new solutions with regard to those existing today (for example Adaptive Cruise Control or Stop and Go) which will not be sufficient at a medium-term and a long-term,
3. to integrate massively high level active safety systems (example automatic braking emergency system) and high level passive safety devices (example the ignition of an air bag) in all range of vehicles (low range to premium range) to be online with the objectives of the European Commission concerning the road safety
4. to offer to all customers, vehicles including active and passive safety systems at a lower cost and with a high level of reliability to guarantee less intrusive functions where the driver remains the master of his vehicle.

Indeed, studies of the institute GIDAS (Fig 1) and NHTSA (Fig 2) show that accidents on the lateral parts and rear parts of a vehicle are also important in comparison with the front of a vehicle.

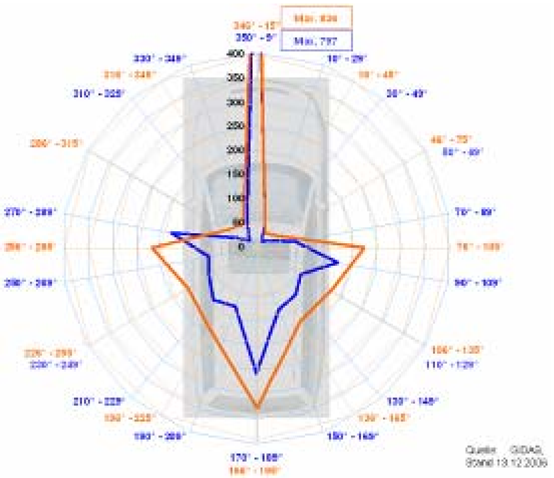


Fig.1: Studies of the institute GIDAS (German In-Depth Accident Study) – statistics of direction of impacts on a vehicle

Fig. 2: Studies of the institute NHTSA (National Highway Traffic Safety Administration) – statistics of direction of impacts on a vehicle

PROJECT ORGANISATION

ARPOD project is led by Autocruise (a TRW Company) as project coordinator. It started on June 2009 and will run until the middle of 2012. Six work packages comprise the organisational frame work of the project, each led by one of the main partners:

1. Management: Autocruise
2. Technical specification: PSA, Autocruise, Gennsys
3. Architecture systems: all partners
4. Development:
    a. Sensor Concept (76 GHz / 79 GHz UWB): Autocruise, Telecom Bretagne, ISAE
    b. Sensor Integration in a bumper: Faurecia, PSA, Autocruise, Telecom Bretagne
    c. Acquisition and Fusion of data: Geensys, from ISAE, Autocruise
5. Sensor Integration in the vehicle: Autocruise, Geensys, Faurecia
6. Validation in a vehicule: Autocruise, PSA, Geensys

PROJECT PURPOSE

The progressive safety systems will be developed through the manufacturing of an “intelligent bumper” peripheral to the vehicle in answering new features as:

1. LCA : Lane Change Assistant,
2. BSD : Blind Spot Detection,
3. FCW : Forward Collision Warning,
4. Frontal and Lateral Pre-Crash,
5. ….

This intelligent “safety belt” peripheral to the vehicle (as illustrated on Fig. 3) would allow a faster response of safety systems (airbag, automatic break system…) by a pre-ignition if these functions.

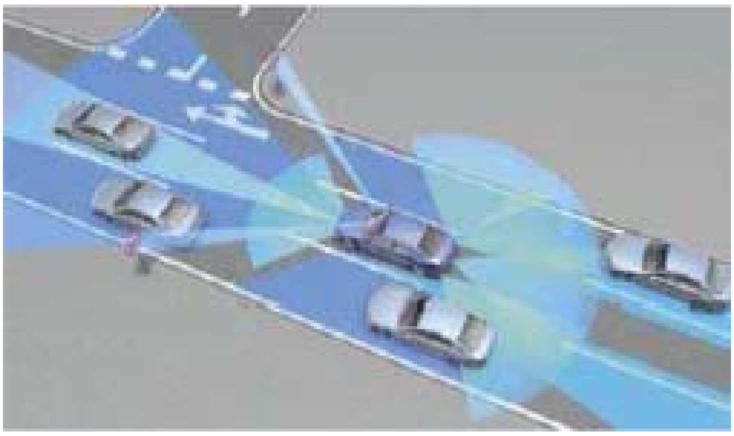


Fig. 3: llustration of the advantages of the bumper around the vehicle

To insure a very good perception of the environment close to the vehicle, the “intelligent bumper” will integrate mini sensors based on 76 GHz / 79 GHz UWB technology peripheral to the vehicle. The fusion of these sensors will allow to have a higher level of information and to get more various functions.

The objective in terms of cost to fill ADAS functions (entire system which would cover the peripheral of the vehicle) have to be very lower than the current ACC (500 Euro). Integration of the “intelligent bumper” on all range of vehicles (low, middle and premium) give perspectives of production higher than the current ACC sensor use only for frontal safety (3 to 4 millions instead of 200 000 a today’s ACC system).

The technologies benefits of multi sensors systems developed in ARPOD Project for the road safety application can be important for other sectors such as aeronautics (for example guidance on the ground of planes), the railway, the sectors of security and of defence, the property of equipment, etc.

PROJECT MAIN OBJECTIVES

The main technical, scientific and socio-political goals of the ARPOD Project are

1. Demonstrate the concept on a representative vehicle according the occurrence defined by pre-crash,
2. Validate ADAS functions such as the parking assistance and detection of the pedestrian in front of the vehicle,
3. Validate the feasibility of the sensor integration in the bumper by taking account the constraints of the design and the manufacturing process,
4. Validate technologies and architectures chosen online to:
    a. the objectives of cost
    b. the reliability of the system,
    c. the flexibility of the system,
    d. the upgrading of the system.
5. Increase the development of the sensor concept with his mass use from 2012-2013,
6. Increase the competitiveness of the implicated partners,
7. Integrate to all ranges of vehicles high safety systems today limited to premium vehicle.

ADVANTAGE OF THE SOLUTION DEVELOPPED IN THE PROJECT

The main benefit of the solution based on mini sensor 76 GHz / 79 GHz UWB peripheral to the vehicle are respectively:

1. their performances and their flexibilities in terms of the peak power, wave shape and receiver sensibility because a chip set MMIC 76 GHz thanks to a fusion of the 76 GHz and 79 GHz UWB sensors in a single sensor compared with radars based on a combination of 24 GHz UWB and 76 GHz sensors,
2. a wavelength three times smaller involving an antenna size three times smaller compared with 24 GHz UWB sensor who brings similar performances of detection but with an antenna size three times greater,
3. a benefit of integration around a factor from 200 to 300 times further to the presence of the SiGe technology in comparison with the AsGa technology which allows to integrate in a more reduced area a single chip for both the analogical and numerical hyper frequencies (emission/reception) parts and low frequencies parts
4. a reduction of the cost around four to five times of the sensor because of the price of the Silicon more competitive than of the AsGa,
5. an integration of the various ADAS functions in a single ECU used at the same time for the treatment of signal radar and supervisory bodies of the vehicle,
6. the classification of an object in a more reliable and fast way, in particular for events including fixed targets to be distinguished from the global environment,
7. a robustness of detection intrinsically better since the peak power is considerably higher in 79 GHz UWB than in 24 GHz UWB or 26 GHz UWB,
8. a risk of lesser interference with 79 GHz UWB with regard to 24 GHz UWB or 26 GHz UWB towards the Fixes services or Mobile Services.

ANNEX 3: OVERALL WORK PLAN AND TIME SCHEDULE

ECC meeting schedule & deliverables requested under the EC Mandate on SRR	**Deliverables for approval by WGFM**	**Comments**
Working period: December 2008 / March 2009		
ECC#22 (9 – 13 March 2009)	**WGFM#65 (9 – 13 February 2009)** **WGSE#52 (26 – 30 January 2009)**	
Interim Report from CEPT to the Commission on Part 1 of the mandate (March 2009)	FM47 to submit to WGFM#65 for approval: • **draft Interim Report – Part 1**: - Review of initial technical assumptions in compatibility studies on SRR 24G - Review of development of SRR 79G - Proposed overall work plan • **Draft LS to WGSE/ SE24**: request to initiate compatibility studies on SRR 26G (24 – 29 GHz)	* *Work in relation with Part 1 of the EC Mandate* 'Review' primarily based on contributions submitted to FMCG-UWB (the results of the "Commission's Call to stakeholders" for input on the fundamental review are expected to be available on 10 February 2009) Provisional conclusion for the draft Interim Report – Part 1: does the existing regulations for SRR 24G and SRR 79G need to be revised or not? Possible outstanding issues to be further investigated as appropriate within the frame of the 'draft Final Report – Part 1'. * *Liaison Statement from WGFM to WGSE / SE24* ETSI draft SRDoc on SRR 26G (TR 102 664 v1.1.1_0.0.7) available for WGSE#52 and WGFM#65. WGFM confirmed at its meeting in February 2009 the request to WGSE/SE24 to initiate compatibility studies, given the tight schedule of the EC mandate. Note: following discussion at ECC meeting in March 2009, WG SE should first limit its work to consideration of evidence to justify additional compatibility studies with the Fixed Service (FS). In the absence of such evidence, the working assumptions are that the existing studies are correct and also applicable to the 28 and 32 GHz bands.

Working period: March / June 2009		
ECC#23 (22 – 26 June 2009)	**WGFM#66 (18 – 22 May 2009)** **WGSE#53 (4 – 8 May 2009)**	
No deliverable requested under EC Mandate on SRR	FM47 to focus on the development of an assessment of automotive SRR. FM47 to submit to WGFM#66 for consideration: • Proposed structure for the assessment of automotive SRR	* *Work in relation with Part 1 of the EC Mandate* Consideration of possible outstanding issues to be further investigated as appropriate within the frame of the 'draft Final Report – Part 1'. Other consideration of the results of the "Commission's Call to stakeholders" should be handled under proposed "assessment of the automotive SRR" (see Part 2). * *Work in relation with Part 2 of the EC Mandate* The Mandate calls for the consideration of "alternative bands". FM47 will have to identify and describe the different regulatory options, taking into account ETSI SRDoc on SRR 26G and the results of the "Commission's Call to stakeholders". An "assessment of automotive SRR", based on guidance given in ECC Report 125, is proposed to be developed by FM47 in order to assess the justification for possible new regulation, and more generally to assess the impact of policy proposals. This IA should be handled in accordance with the recommendations currently developed by WGRA on how to manage Impact Assessments in the ECC structure. * *Support needed from WGSE / SE24* Following discussion at ECC meeting in March 2009, WG SE should first limit its work to consideration of evidence to justify additional compatibility studies with the Fixed Service (FS). In the absence of such evidence, the working assumptions are that the existing studies are correct and also applicable to the 28 and 32 GHz bands.FM47 will take account of any new information from WGSE/SE24

Working period: June / October 2009		
ECC#24 (26 – 30 October 2009)	**WGFM#67 (5 – 9 October 2009)** **WGSE#54 (7 – 11 September 2009)**	
Final Report from CEPT to the Commission on Part 1 of the mandate (October 2009) Interim Report from CEPT to the Commission on Part 2 of the mandate (October 2009)	FM47 to focus on the development of an assessment of automotive SRR. FM47 to submit to WGFM#67 for approval: • **draft Final Report – Part 1** • **draft Interim Report – Part 2:** - Preliminary Assessment of automotiveSRR (summary) - Provisional results of compatibility studies on SRR 26G (24 – 29 GHz)*	* *Work in relation with Part 1 of the EC Mandate* Finalization of possible outstanding issues. * *Work in relation with Part 2 of the EC Mandate* Development of the Assessment report. * *Support needed from WGSE / SE24* Provisional results of compatibility studies on SRR 26G (September 2009) *.
Working period: October 2009 / January 2010		
ECC#25 (1 – 5 March 2010)	**WGFM#68 (January 2010)** **WGSE#55 (January 2010)**	
Final Report from CEPT to the Commission on Part 2 of the mandate (March 2010)	FM47 to submit to WGFM#68 for approval: • **draft Final Report – Part 2:** - Assessment of the automotive SRR (summary) - Final results of compatibility studies on SRR 26G (24 – 29 GHz)* - Recommendations and conclusions	* *Work in relation with Part 2 of the EC Mandate* Finalisation of the Assessment report. * *Support needed from WGSE / SE24* Final results of compatibility studies on SRR 26G (January 2010) *.

* Note: pending conclusion during March / June 2009 working period on the consideration of evidence to justify additional compatibility studies with the Fixed Service (FS). In the absence of such evidence, the working assumptions are that the existing studies are correct and also applicable to the 28 and 32 GHz bands.