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DESIGN OF EFFECTIVE COLLISION MITIGATION SYSTEMS AND PREDICTION OF THEIR STATISTICAL EFFICIENCY TO AVOID OR MITIGATE REAL WORLD ACCIDENTS

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ABSTRACT

Primary safety systems are designed to help to avoid accidents or, if that is not possible, to stabilize respectively reduce the dynamics of the vehicle to such an extent that the secondary safety measures are able to act best possible. The effectiveness is a measure for the efficiency, with which a safety system succeeds in achieving this target within its range of operation in interaction with driver and vehicle. Based on Daimler´s philosophy of the "Real Life Safety" the reflection of the real world accidents in the systems range of operation is both starting point as well as benchmark for its optimization.
A prospective method of efficiency prediction for primary safety systems which yields statistically significant results is discussed for rear-end crashes. The method starts from a characterization of the conflict and the crash situation depicting its relevance in real word accident statistics. The optimization process is aimed at achieving best system performance under the spectrum of real world accidents. The method was applied to the conventional Brake Assist of Mercedes-Benz. The result matches excellently with former retrospective evaluations of German accident statistics. The appliance to the linkage of DISTRONIC PLUS with Brake Assist PLUS generated promising results. Despite very conservative restrictions the results confirm with the profound safety effects: DISTRONIC PLUS and Brake Assist PLUS can avoid more than 20% of all rear-end collisions. In an additional portion of 25% of collisions the linked systems contribute to a significant reduction of accident severity.

INTRODUCTION

For Mercedes-Benz, automotive safety is not just a question of fulfilling crash tests. Mercedes´s innovations in the area of primary and secondary safety have been based successfully on findings of accident research for 38 years. Reality still is and continues to be the benchmark of the development of effective primary and secondary safety measures. The development of modern safety measures is a holistic process (figure 1) which is based on accident research, basic research on driver behaviour (situation based human or operating error) and development and integration of new sensor, perception and actuator technologies. During the development process ample simulation series [6], system tests at test areas [5] and driving simulator tests are used to design and optimize the assistance systems [3]. During the final step customer-orientated testing of the system is carried out. However, after the system is introduced to the market it takes several additional years for it to penetrate the market. Only then is it possible to gain information on its efficiency based on real world accident statistics. Many of these systems take more than a decade of years to achieve a sufficient penetration rate. This immense lag of time is not acceptable for the development of safety measures that had to be efficient on the base of reality like it is required by Mercedes-Benz.

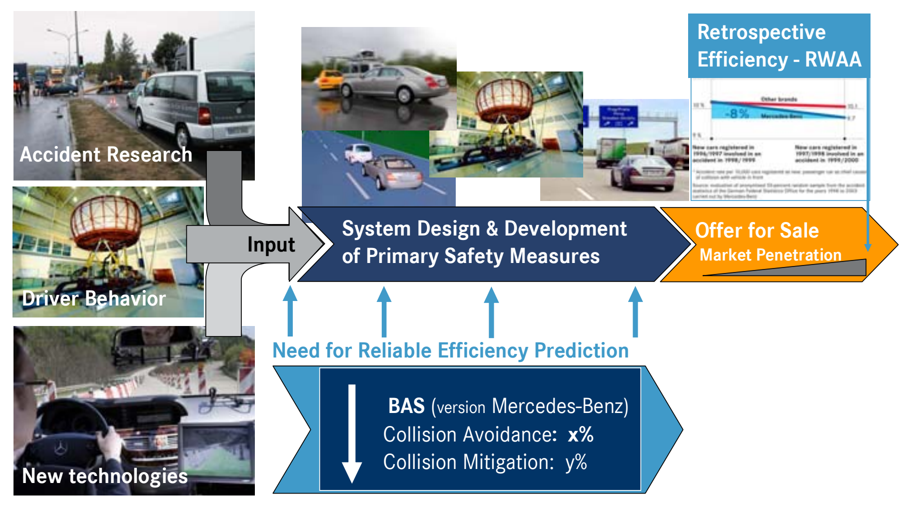


Figure 1: The need for statistically significant efficiency prediction during the development of safety measures and beyond

For the optimization of the above described development process it is essential having statistically reliable prediction of the expected efficiency available continuously from the choice of a promising idea for the design of a new safety measure, the starting point of its development and through the whole process. So it becomes possible

- to focus on those primary safety measure that addresses most efficient relevant accidents and conflict situations resulting from human errors,
- to configure an efficient set of optimal balanced sensors, actuators and algorithms,
- to optimize the efficiency of the function by preliminary design using simulation methods,
- to obtain reliable information what the customer can expect from the system as benefit.

Efficiency analysis is the key technology to achieve an improved development process.

DEFINITIONS

In analyzing the effect of primary safety measures it is useful to define terms that describe abstract characteristics of an accident or concrete accidents of a given characteristic. The characteristic could be a parameter that leads to an accident like the conflict, an environmental parameter like ice or a property like skidding. Another useful differentiation is that between the relative and the absolute effect. To do so the following definitions were introduced (see figure 2).

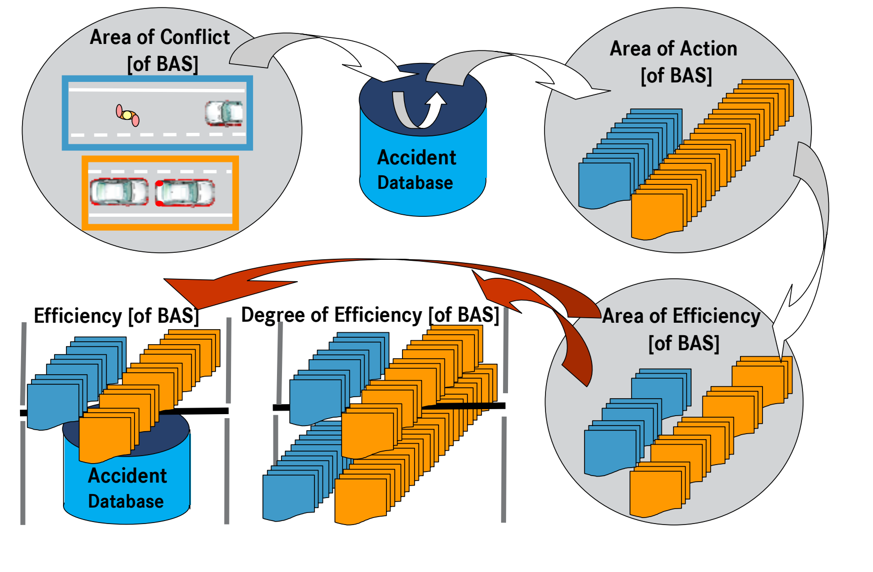


Figure 2: Visualization of the definitions around efficiency

The **area of conflict** [**AoC**] of a primary safety measure is defined to be the grouping of abstract standardized conflict situations, in which the primary safety measure should operate, avoiding or reducing accident severity due to its specifications. Use-cases which can be categorized as accidents are an example that makes up an “area of conflict”. The **area of action** [**AoA**] is defined as the mapping of the area of

conflict in representative real life accident data. It is the totality of accidents which correspond to the conflict situations in the area of conflict.
The **area of efficiency** [**AoE**] is defined as the subset of the area of action, in which the primary safety measure is able to avoid or mitigate the severity of accidents. Here the design specifications satisfy the physical parameters of the accidents.
The **degree of efficiency** [**DoE**] is defined as the quotient of the number of accidents in the area of efficiency and in the area of action. The **efficiency** is defined as the quotient of the number of accidents in the area of efficiency and the number of accidents in the origin base of all accidents. The adjunct “representative” is used to clarify that the allocation base was representative. An illustration of the terms defined above and their dependencies is shown in Figure 2 using the primary safety measure “Brake Assist (BAS)” as an example.

METHODS FOR DETERMING EFFICIENCY

First of all methods for determining the efficiency of primary safety systems can initially be classified according to their ability to provide results for efficiency in a retrospect or in a prospective view.
Methods for a retrospect assessment of efficiency have established themselves by proving the evidence of ESP. Studies conducted by Mercedes-Benz [1], NHTSA and others show that in a representative sample of accidents a significant reduction in the number or the severity of special types of accidents between a group of cars equipped with ESP and a group of cars without ESP could be observed. One of these special types is for example the type of “driver related accidents”. Mercedes-Benz showed a reduction of 42% in this type of accident. This result is confirmed by other studies and already existing meta-studies [2]. By contrast in [13] not a type of an accident but the conflict of a skidding car before the crash is analyzed.
The principle disadvantage of retrospect methods is that they base on the fact that there is a significant amount of cars equipped with the system in the market and that they are differentiable from those without the system. This penetration normally needs years after the point of sale. This is unacceptable for a use in the development of effective safety systems.
The prospective methods can be distinguished by their ability to supply statistically reliable representative results. The following requirements have to be fulfilled to obtain such results:

1. *representative accident database used as a basis for the method / analysis*
   this means in particular a great number of total and considered accidents, surveyed coincidentally, containing all required information by the primary safety system
2. *reproducibility of the results respectively the determination of AoA and AoE*
   this means especially a strictly rule-based respectively automated approach
3. *integration of most / all parts of the primary safety system in the estimation of AoE*
   this means integrating descriptions or models for most or all parts of the system in the loop with car, driver and the complex accident situations in their holistic interactive dependencies (for the prevention of drastic simplifications).

An assessment of common used method for predicting efficiency in the two dimensions “representative database” and “level of details of integrated parts” is shown in figure 3.
The “method” driving simulator has the unique advantage that it makes it possible to vary the driver and its behaviour in the accident situation remaining the same for all different drivers. To cover the wide spread of conflicts that lead to a rear-end accident the efficiency is calculated as a mean of several typical rear-end accidents [3, 4, 14, 16]. For getting representative results the integration in other methods is necessary.
The determination of AoE which is necessary to calculate DoE can be done in two ways. The simple way is to integrate parts of the primary safety system in the specification of AoE. If AoA and AoE are determined from in-depth accident data, this could be done. An example of

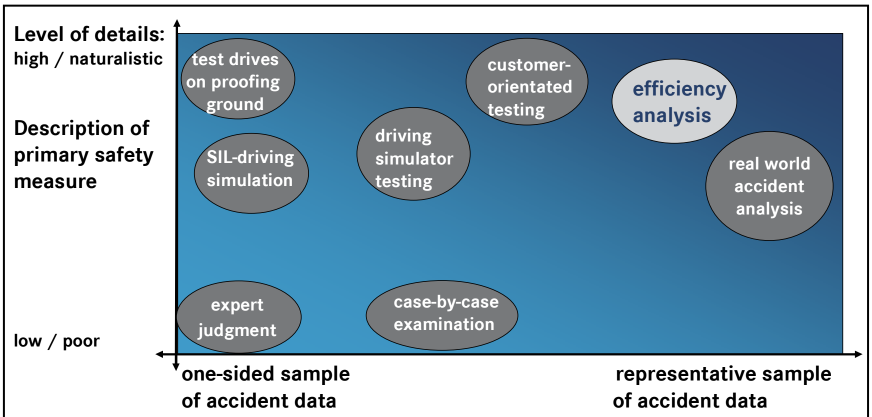


Figure 3: Efficiency assessment methods and their characteristics

doing this is described in [7, 8]. A weakness of this approach is the not neglectable variance in the results. A more complex and expensive way is to determine AoE by an automatically performed analysis of all accidents contained in the AoA [8, 9]. This approach ends in a trustier AoE and DoE than the one resulting from the simplified approach described before. Therefore a specific version of an automated approach is used in this paper.

GIDAS DATABASE-A STATISTICAL REPRESENTATIVE SAMPLE OF ACCIDENTS

The analysis in this paper is based on accident data provided by the GIDAS project. GIDAS is an abbreviation for "German In-Depth Accident Study". GIDAS is a cooperative project between the German Association for Automotive Technology Research (Forschungsvereinigung Automobiltechnik e.V., FAT) and the German Federal Highway Research Institute (Bundesanstalt für Straßenwesen, BASt) (see [11] for more details). In its current form it was founded in 1999. Since this time the data for in-depth documentations of more than 2000 accidents per year is collected in two research areas – the metropolitan areas around Hanover and Dresden (figure 4). The criterions for choice and collection are: (1) road accident, (2) accident in one of the research areas, (3) accident occurs when a team is on duty, and (4) at least one person in the accident is injured, regardless of severity. For each accident a digital folder is delivered according to carefully defined guidelines and coded in a database. Depending on the type of accident, each case is described by a total of 500 to 3,000 variables, containing e.g. accident type and environmental conditions (the type of road, number of lanes, width, surface, weather conditions, time of the day,…) surroundings of the accident scene, vehicle-type, vehicle specifications (mass, power, tires, …) and configurations (e.g. with safety measures), documentation of damage of the vehicles and injury data for all persons involved and their medical care. Investigation of all cases is "on the spot" to ensure best visibility of traces for a best possible reconstruction. Each accident is reconstructed in detail including the pre-collision-phase. Available information includes initial vehicle and collision impact speed deceleration as well as the collision sequence.

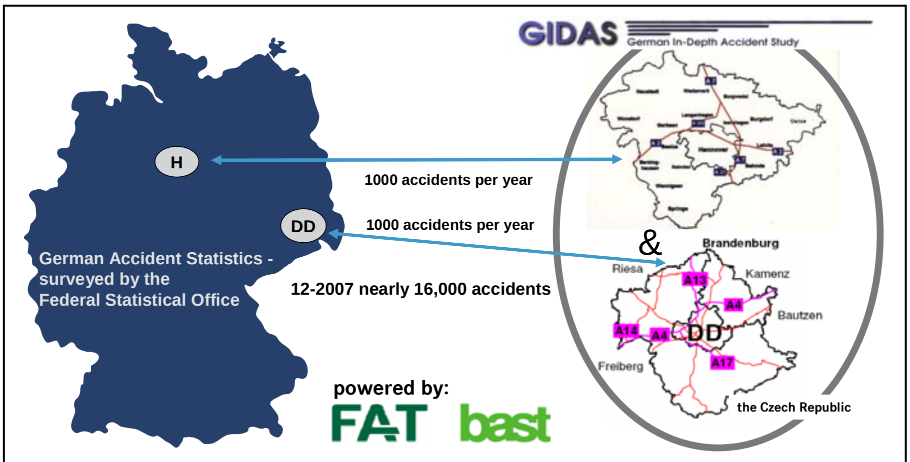


Figure 4: GIDAS database - the research areas around Hanover and Dresden

Half the battle of the pro of this database is that: (1) the number of cases is high enough to provide statistically significant results, and

(2) each accident is documented in great detail, including in-depth-analyses and reconstructions of the course of the accidents including the pre-crash phase, and (3) most of all this database is proven to be representative to German national accident statistics.

RELEVANCE OF REAR-END CRASHES WITH PERSONAL INJURY IN GERMANY

Rear-end collisions are among the most frequent type of accidents with injury outcome. In the German accident statistic of 2006 this accident type corresponds to 15% of all accidents with injuries. Taking a closer look at rear-end collisions it becomes clear that only four conflict situations already make up 80% of all rear-end collisions: (1) colliding with a slower vehicle, travelling in front,(2) colliding with a vehicle at the tail end of a traffic jam,(3) colliding with a vehicle which stops, brakes or travels slowly due to an impending stop (traffic light, stop sign, etc.), and (4) colliding with a vehicle which attempts to turn left but needs to stop for another vehicle having the right of way (figure 5). We will refer to these accidents as the

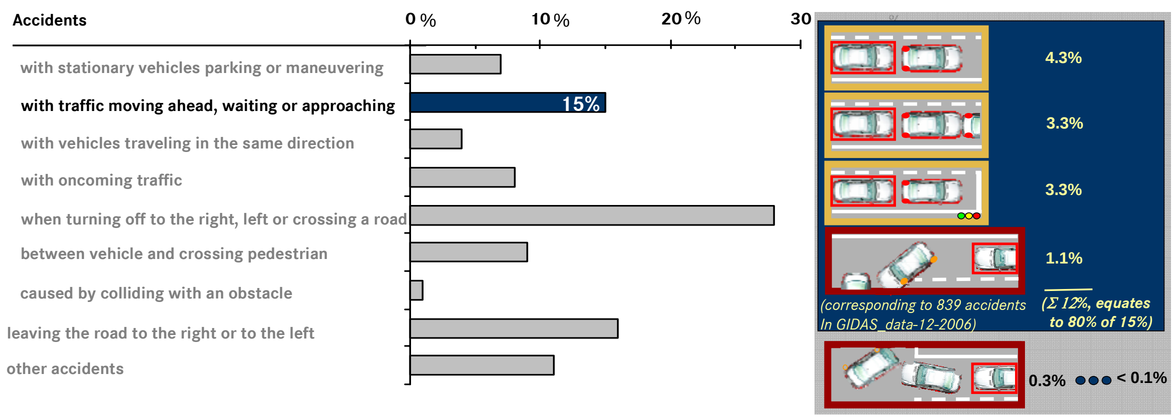


Figure 5: The *area of action* of CRAMS addressing rear-end collision correspond with 15% of all accidents with injuries in German accident statistics of 2006. 80% of all collisions result from only 4 conflict situations.

"*Area of Action of CRAMS*" (**C**ollision (**R**ear-end) **A**voidance or **M**itigation **S**ystems). The absolute size of other conflicts is less than 0.1%. For reducing complexity we will leave them out from further considerations. But where do these accidents happen? Accident statistics give us a good indication: 62,2% in urban areas and 37,8% outside urban areas. The accidents happening outside urban areas can be subdivided into three different types of roads: 15% of these accidents happen on freeways, 11,5% on highways and another 11,3% on roads of lower categories. Each type of road defines a specific dynamic representation of the accidents situations which should be addressed by the primary safety measure efficiently. For details see figure 6. Hard point for reducing fatalities is the reduction of extra urban accidents on motor- and freeways. Crucial point for reducing the number of accidents is the focus on "urban accidents".

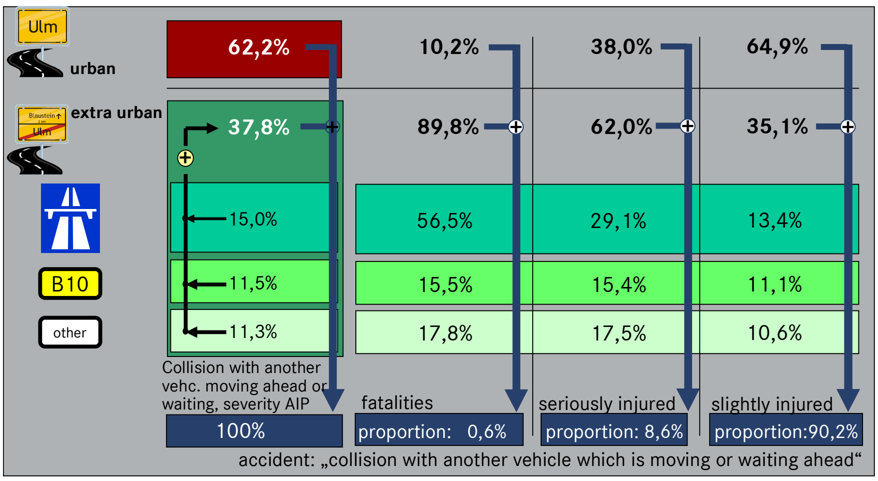


Figure 6: Sites of rear-end accidents with personal injury (API) in Germany (2006)

FROM BRAKE ASSIST TO BRAKE ASSIST PLUS

Brake Assist was the first primary safety measure that provides provable assistance to the driver to avoid rear-end collisions. It was derived from the observation [14] that drivers apply the brakes in emergency situations fast but normally did not reach maximum capability of the brake system. Brake Assist (BAS) identifies emergency braking situation by always comparing the speed at which the brake pedal is activated. If this speed exceeds a specific limit which also depends on the current velocity of the car and an actuation travel of the brake pedal, Brake Assist automatically builds up the highest brake pressure. The deceleration increases instantly to the maximum possible value. It was due to the decision of Mercedes-Benz to install BAS 1997/98 as standard equipment in all passenger cars that the efficiency of the system was measurable in the national German accident statistics of 1999/2000. BAS reduces the involvement of Mercedes-Benz cars in contrast to cars of other brands in rear-end collision by 8% (see figure 7) and in serious accidents with pedestrians by 13% [12, 16].

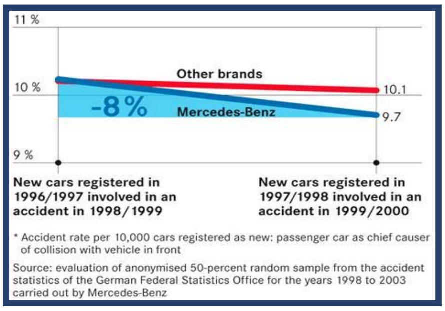


Figure 7: Efficiency of BAS in rear-end accidents, figures from the national German accident statistic of 1998/2000

Selective further development of BAS [3, 4] was "added environmental sensing" i.e. the integration of two radar sensors systems to monitor and evaluate the traffic situation in front of the car. The 77-GHz and two 24-GHz radar systems complement each other. The 77-GHz long-range radar is able to scan three lanes over a distance up to 150 meters with an angel of nine degrees. Two 24-GHz radar sensors monitor the immediate area in front of the vehicle from 0.2 up to 30 meter with an angle of 80 degree for each sensor. With this radar-based environmental perception the situation evaluation algorithm of BAS PLUS can detect imminent rear-end collisions to identified obstacles. If there is currently one detected BAS PLUS does in parallel:

(1) BAS PLUS calculates continuously the actual braking assistance required to avoid the collision by target braking (not necessarily a full braking). The calculated braking pressure is available as soon as the driver applies the brake.

While the conventional Brake Assist requires a reflex activation of the brake pedal, BAS PLUS only requires a pressure on the pedal that shows the clear intention for braking. This measure increases the number of activations considerably compared to BAS [14]. While the conventional BAS only can provide full braking pressure, BAS PLUS provides a situational depending braking pressure needed for a target braking.

(2) BAS PLUS warns the driver with an audible signal, prompting him to take action.

This warning sub function is an additional difference between conventional BAS and BAS PLUS. Thereby BAS PLUS is able to support drivers that misjudge criticality, react inert or got distracted. This warning increases the number of driver braking in these conflicts.

The BAS PLUS system is an additional option efficient especially in the case of rear-end collisions; naturally the BAS remains available. It keeps very efficient in accidents with pedestrians, where an alert driver sticks to be a more efficient sensor compared to radar.

FROM DISTRONIC TO DISTRONIC PLUS

Mercedes-Benz calls his advanced cruise control DISTRONIC (DTR). It was presented in 1998. The system combines the cruise control function with a 77 Gigahertz long-range radar sensor. For an intrinsic speed in the range between 30 to 180 km/h DTR can set a value for

vehicle speed and another value for a time based distance maintaining to a vehicle in front. Below an intrinsic speed of 30 km/h DISTRONIC automatically switches off. Its maximum dynamic to decelerate is 2 m/sec². The assisting System DISTRONIC tries to keep the vehicle at the desired speed until it detects a slower vehicle in front. In this case DTR reduces the intrinsic speed so that the planned distance to the car in front is kept. If DTR reaches its system limits the control task is handed over to the driver. DISTRONIC also contains optical and audible collision warning.
Selective further developments of DISTRONIC lead to DISTRONIC PLUS [3, 4] in 2005. The 77 GHz DISTRONIC radar was combined with two 24 GHz short range radar sensors. The algorithms for situation perception and assessment were enhanced. This leads to an increased operating range from 0 km/h to 200 km/h, an extend of the area of operation of the proximity control up to between 0.2 m and 150 m and an advanced dynamic range for deceleration. As such, automatic braking is now provided up to 4m/s² depending on the intrinsic speed. Where are the differences between DISTRONIC and DISTRONIC PLUS that are relevant for their ability to mitigate or if physically possible avoid rear-end accidents?
While the conventional DTR can not …

- automatically brake to a standstill, DISTRONIC PLUS can.
- “sense” a car standing still after braking to standstill DISTRONIC PLUS can.
- decelerate with more than 2 m/sec² DISTRONIC PLUS can decelerate automatically with 4m/sec² up to an intrinsic velocity equal 50 km/h, between an intrinsic velocity of 50-150 km/h with an deceleration in the range from 4 m/sec² to 2 m/sec², and above 150 km/h with 2 m/sec².
- control speed and distance in the range from 0-30 km/h for intrinsic velocity and in proximity up to 0.2 meters, DISTRONIC PLUS can.

The advanced situation perception and assessment based on the use of 24-GHz radar, the extended dynamic and enlarged system limits cover the dynamic of more than 50% of rear-end accidents. In sum these additional features give DISTRONIC PLUS the opportunity to mitigate respectively avoid rear-end accidents.

THE REAL WORLD EFFICIENCY OF BAS LINKED WITH DISTRONIC AND BAS PLUS LINKED WITH DISTRONIC PLUS

In the two preceding sections the functionality of Brake Assist, Brake Assist PLUS, DISTRONIC and DISTRONIC PLUS was represented in detail. Now their degree of efficiency in avoiding or reducing the severity of rear-end accidents based on real world data will be examined. To be able to do so a virtual proving ground was created consisting of models for vehicle with primary safety system respectively assisting system, driver and environment. The actual realized level of detail permits evaluations of Mercedes-Benz cars equipped with above specified systems BAS, BAS PLUS, DISTRONIC, DISTRONIC PLUS dynamically in those critical pre-crash situations defined by the elements of the relevant areas of action. Analysis for the efficiency is carried out automatically based on the area of action.
The assumptions on which the following efficiency analysis is based are very important, they are chosen very conservative: Selecting accidents from GIDAS database (2006) that belong to “area of action of CRAMS” (AoA-CRAMS) as defined before. Then it holds for AoA-CRAMS:

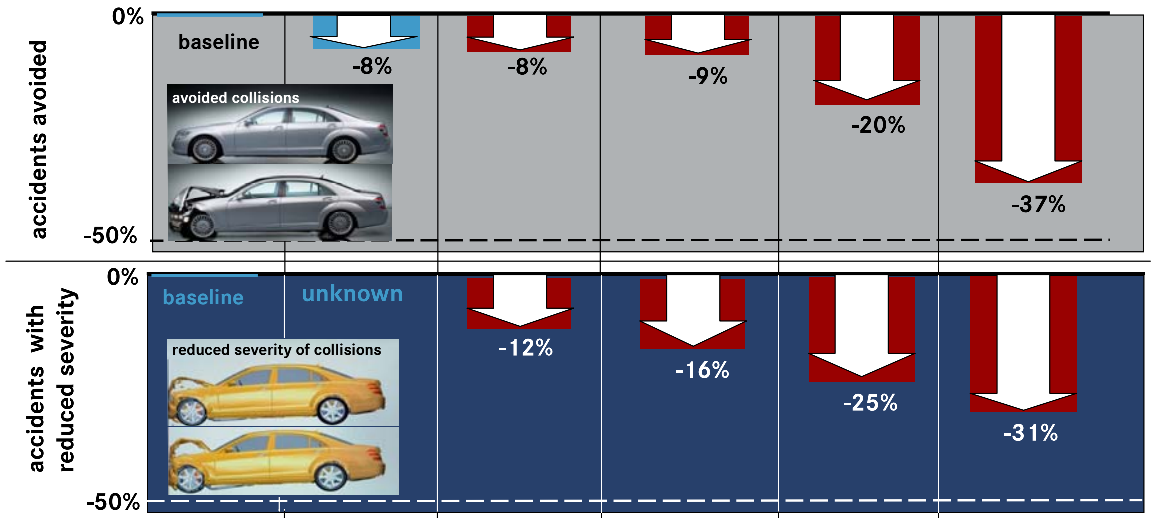
- It consists of 839 in-depth evaluated accidents, especially containing reconstruction data.
- It constitutes a representative sample of rear-end accidents with personal injury in Germany.

The systems BAS, DTR, DISTRONIC PLUS, BAS PLUS are tested virtually in the “**area of action of *CRAMS***” (***C***ollision (***R***ear-end) ***A***voidance or ***M***itigation ***S***ystems) assuming:

- Equipment rate is 0% or 100%.
- BAS PLUS is activated permanently (rate of switching-on is 100%).

- DISTRONIC, DISTRONIC PLUS - adaptive cruise control sub-function - is activated for 100% extra urban driving on freeways (Autobahnen) and highways (Bundesstraßen).
- Conservative assumptions with respect to the behaviour of the driver during the accident:
  - Driver behaviour remains UNCHANGED during the accident (equal to reconstruction).
  - A possible reaction of the driver to all kinds of collision warnings is NOT MODELED.
  - A simple driver model for activating BAS is used.

The degree of efficiency is calculated as defined before.



BAS	-	YES	YES	YES	YES	YES
DISTRONIC	-	-	-	YES	-	-
DISTRONIC PLUS	-	-	-	-	YES	YES (on BAB only)
BAS PLUS	-	-	-	-	YES	YES (on BAB only)

Real world accident analysis — Efficiency analysis based on real world accident data (GIDAS)

Assumptions:
- Equipment rate 0% respectively 100%
- BAS PLUS is activated permanently (rate of switching-on is 100%)
- DISTRONIC PLUS- adaptive cruise control - is activated 100% extra urban on freeways (BAB) and highways (Bundesstraßen)
- Conservative assumptions with respect to the behavior of the driver during the accident (no changes, no reaction on warning)

Figure 8: Mercedes-Benz inventions “DISTRONIC, DISTRONIC PLUS linked with BAS respectively BAS PLUS” reduce the number and the severity of rear-end collisions:

Figure 8 summarizes the results of the efficiency analysis for BAS, DISTRONIC linked with BAS respectively DISTRONIC PLUS linked with BAS PLUS based on representative real world accident data. For comparison the result of the retrospective efficiency in the case of rear-end collisions based on data from the German Federal Statistics Office is included in figure 11. This former evaluation shows a reduction of -8% in rear-end collisions resulting from BAS. A similar effect results from the virtual test with vehicles equipped with BAS in the area of action consisting of ALL rear-end crashes from GIDAS (2006). Just over 8% of all rear-end collisions could be avoided during the virtual test of BAS with more than 800 representative accidents with personal injury. [9]
In the case of the combination of BAS and DISTRONIC (switched-on on highways and freeways) the number of avoided rear-end crashes increases to nearly 9%. Here the additional obtained reduction of severity carries more weight. In the case of the combination of BAS PLUS with DISTRONIC PLUS (switched-on on highways and freeways!) the share of avoided accidents (in all urban and extra urban collisions) climbs above 20%. The proportion of accidents with reduced severity adds to it with 25%. The safety potential of the interaction of DISTRONIC PLUS and BAS PLUS becomes even more evident on freeways. Here the system combination is able to avoid more than 37% of all rear-end collisions. This is due to the large share of accidents in which drivers do not react. In more than 85% of all accidents

were the driver did not react a switched-on DISTRONIC PLUS is able to avoid accidents due to its (increased) wide dynamic range. This is all the more amazing due to the fact that the additional effect of a warning is ignored. In those accidents in which the driver brakes so far, DISTRONIC PLUS reduces energy in the bullet car until the point in time when the driver applies the brake thus far. After this point BAS PLUS optimizes braking reaction of the driver to a target brake. This avoids many accidents or reduces their severity especially in the situations with traffic jam. This optimal functionality in complementing one another leads in sum to an absolute portion of nearly 4% of the total amount of nearly 21 % avoided accidents. All numbers based on an 80% proportion of accident situations maintaining to rear-end crashes. A future dropping of the restriction to (CRAMS-AoA) and consideration of all accident situations may give an increased efficiency. The work will be continued to integrate the efficiency of PreSafe®-Brake and the reaction of the driver on warnings.

SIMPLIFIED ANALYSIS OF THE INFLUENCE OF THE DRIVER

The following assumptions about the driver were made in the previous efficiency analysis:

- Driver behaviour remains unchanged during the accident (equal to reconstruction data).
- A possible reaction of the driver on all kinds of collision warnings is NOT MODELED.

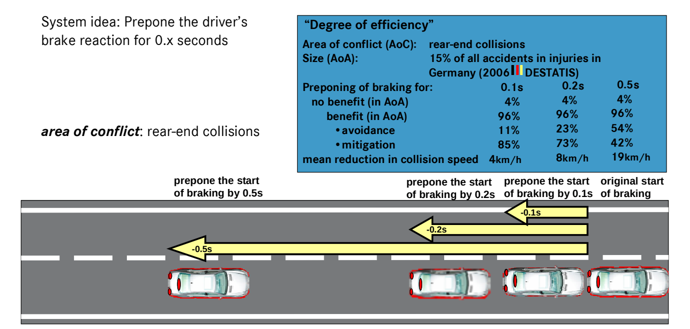
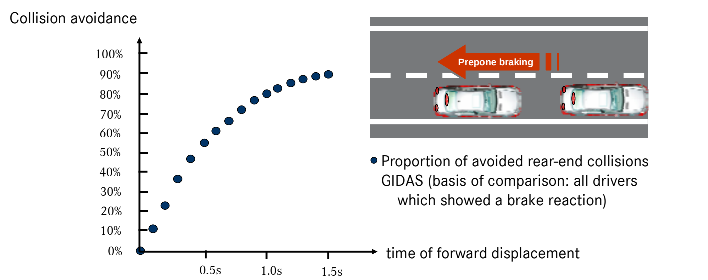


Figure 9: Degree of efficiency of preponed braking in rear-end collisions

What is that suppose to mean? A warning can effect 2 basic reactions: (1) if the driver does not react in the original accident without a warning, it is to be assumed that he would do so – with a certain probability. (2) if the driver reacts in the original accident, two different cases have to distinguished: (a) the reaction was before he could be aware of the warning, then it is to be assumed that the warning would have had no influence on the point in time of his reaction.
(b) the reaction was after the warning, then it is to be assumed that the warning would have had influence on the point in time of his reaction. With a certain probability the collision warning will lead to a preponing of the reaction – close(r) to the warning. In none of these cases the (observed) reaction point in time would have been regarded stable or preponed by the warning. So the assumptions made are very conservative, but the consideration of a driver reaction on the warning would (only) improve but in no case impair the efficiencies.



(Starting point is the set of all rear-end crashes caused by passenger cars in GIDAS 2006, (N=839), *area of action* is chosen to be the subset of all accidents with brake reactions, considering road conditions and surface in the analysis.)

Figure 10: Prepone the driver's brake reaction in time - parameter study showing proportion of avoided rear-end crashes

Figure 9 and 10 show simplified the efficiency of a preponing of brake reaction in time for all drivers who already show a break reaction. An average of 0.2sec - 0.3sec for the preponing of a brake reaction initialised by a warning and 0.2sec - 0.3ses for a dynamic brake system – like those that were used in luxury cars like the S-class - seem to be realistic. [9]

SUMMARY

A prospective method of efficiency prediction for safety systems which yields statistically significant results is realized for rear-end crashes. The method was applied to BAS. The results match excellently with former retrospective evaluations of German accident statistics. The appliance to the linkage of DISTRONIC PLUS (switched-on) with BAS PLUS has generated promising results. Despite the very conservative restrictions the results confirm the profound safety effects: DISTRONIC PLUS and Brake Assist PLUS can avoid more than 20% of all rear-end collisions. In an additional portion of 25% of collisions the linked systems contribute to a significant reduction of accident severity.

The method has proved to be usable to evaluate the efficiency of simple and complex / realistic primary safety systems on the base of representative accident data with maintainable effort. It is applicable to optimize algorithms as well as environmental perception equipments. It could be used to determine the probable effect of a concept just as well as the effectiveness of an existing system with a small penetration in the market which is invisible in accident statistics. The next step is the integration into the vehicle development and process chain of Daimler. Thereby the implementation of the most effective measures on the way to “accident-free driving” should be identified and realized [17, 18].

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[17] Schöneburg, R., Breitling, T.: Enhancement of active and passive safety by future pre-safe systems, Paper No. 05-0080, ESV-Conference 2005, Nagoya, 2005

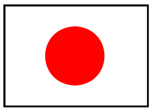
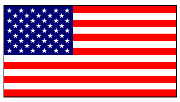
[18] Justen, R.: New ways of safe driving, FISITA-Congress 2008, F2008-08-056, 2008

Potential Real World safety opportunities with UWB SRR in Japan.

April 2009
Autoliv

Slide: 1

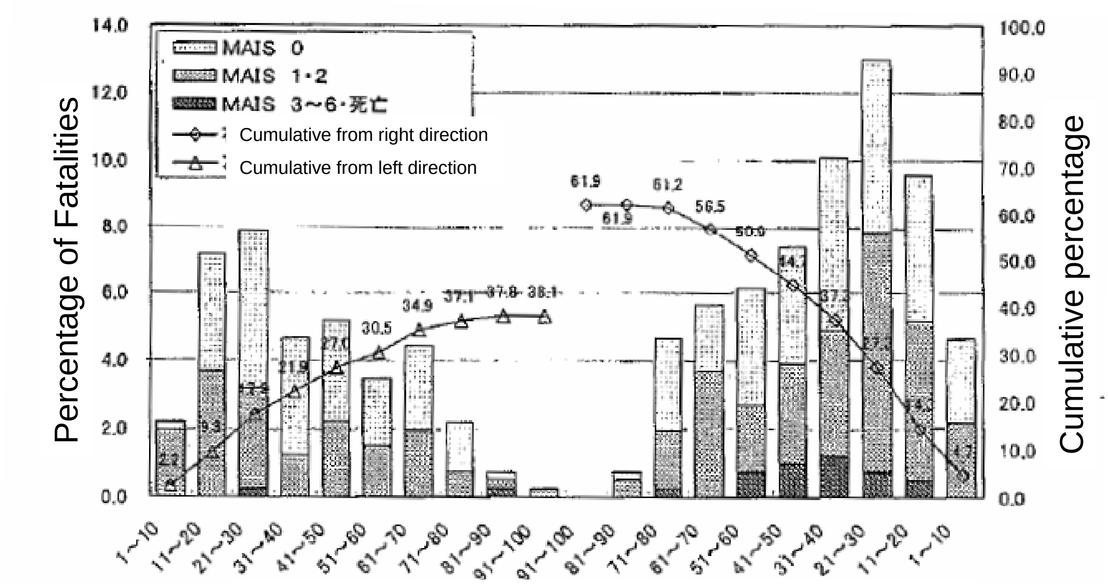
Global road traffic accident similarities.

				Origin of Data
First age class victim of fatal accidents	>65 years old (42%)	[16-20 years] (highest fatality rate)	[24-65 years] (54%)	Japan: National Police Agency 2004 EU: CARE 2004-EU14 US: FARS 2005
Most frequent fatal accident victim	Vehicle occupants(40%) (Pedestrian(30%) 2 Wheels (30%))	Vehicle occupants (76%)	Vehicle occupants (50 to 55%)	Jama 2007 National Police Agency 2006
Vehicle occupants: Fatalities in frontal collisions	76%	52%	34%	**Toyota ESV 2007** **TRL ESV 2007** **US: FARS 2005**
Vehicle occupants: Fatalities in side collisions	19%	17.9% left 16.2% right	48% in UK 39% in Germany	**Toyota ESV2007** **ETSC 2001** **US: FARS2005**

As per EU and US, frontal accidents is a significant portion of overall accident

Slide: 2

Accident mode: Small Overlap



ITARDA Annual Report (2003)

(Left Direction) Overlap Ratio (Right Direction)

As in EU and US, Small overlap (<30%) represent a significant portion of collisions and MAIS3+

Autoliv

Consequent requirements for Sensing:

High reliability of decision on marginal cases

Significant proportion of Small Overlaps
and
Avoid false decisions on near-hit cases

High resolution around car edges

Autoliv

Complex road infrastructure

Suburban area:

- Narrow streets with protruding electric poles or rigid equipment.
- Few night illumination
- Few sidewalks

Urban area:

- Traffic mix.
- High traffic density.
- Driver flooded with visual information/signals.

Consequent requirements for Sensing:

High capability for separation

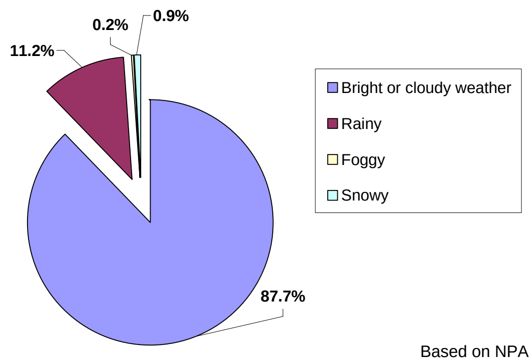
High proportion of severe pedestrian accidents
+
High traffic mix
+
Dense traffic

↓

High Resolution

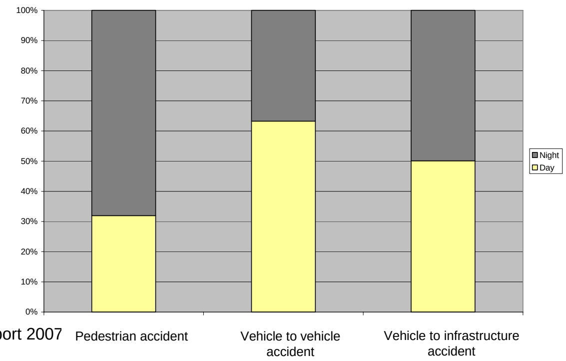
Weather and light conditions

Weather conditions for fatal accidents



Based on NPA report 2007

Portion of fatal accident depending on daylight



Based on NPA report 2007

Majority of fatal accidents occur after daylight, and about 12% occur in difficult visibility conditions

Consequent requirements for Sensing:

High sensor availability

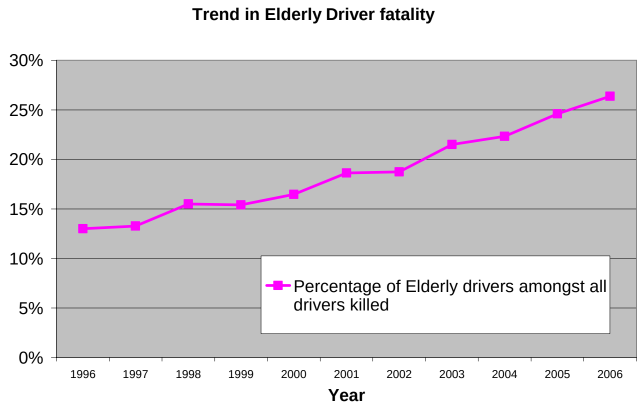
Severe accidents frequent at night time

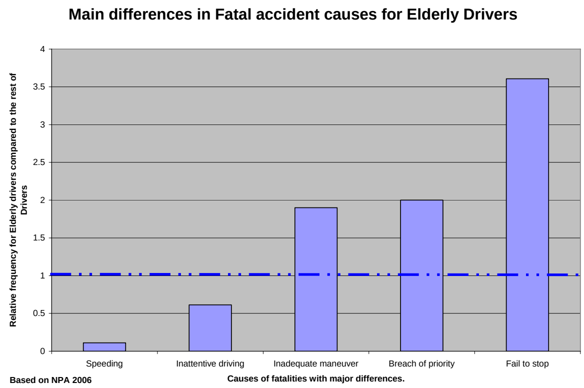
+

Accident in difficult weather condition can not be dismissed

High sensor availability

Elderly drivers





Even more than EU and US, Elderly Driver fatalities is an increasing issue.
Elderly drivers show slower reactions, tend to be overwhelmed by warnings/signals: Active control would be more efficient.

Consequent requirements for Sensing:

High sensor reliability

Vehicle control

High sensor decision reliability

Spatial Resolution

Angle and distance

Resolution in this context is defined as the ability to separate or resolve two closely spaced targets.
For a simple radar with no measurement capability vertically (elevation), resolution comes from three, mostly independent parameters: Velocity, Target Angle and Distance (in conventional polar terminology)

Angular resolution is primarily driven by physical antenna aperture, irrespective of how that aperture is realized. For example, for an array, the narrowest synthesizable beam width can be calculated from the total physical dimensions *(ref "Antenna Theory", Constantine Balanis, 1982, pp222).*

A typical SRR receive antenna aperture of ~6cm is probably the maximum feasible , leaving enough physical space and separation for the transmit antenna (or vice versa) for a total unit size of the order of 10cm or less. Thus we can calculate the maximum 3db beam width, which will determine our angular resolution.

3dB Beam width: $\Phi = 2*(90 - \cos^{-1}(-0.443(\lambda/D))$ (λ: wavelength, D: physical antenna aperture)

For D=6cm, this yields Φ =10.6 degree

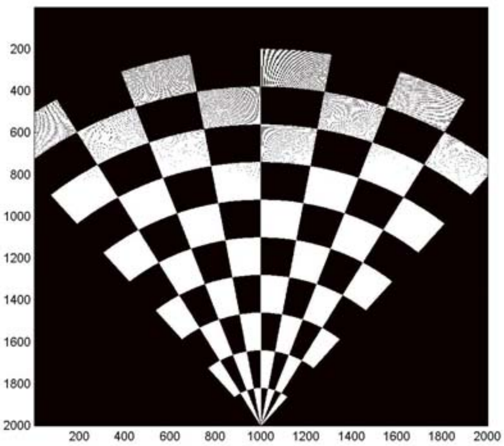
Of course, this resolution figure can be improved upon using super-resolution techniques such as the MUSIC algorithm, but such approaches trade SNR for angular resolution (while significantly increasing the processing load and thus cost).

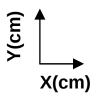
Distance Resolution is simply related to swept or instantaneous RF bandwidth (for FMCW and pulse systems respectively). For narrow band allocations in the ISM band in Japan, occupied bandwidth is restricted to ~80MHz. FCC and ETSI regulations allow up to at least 2GHz of bandwidth (more like 4GHz). Thus the available distance resolution from the two allocations is

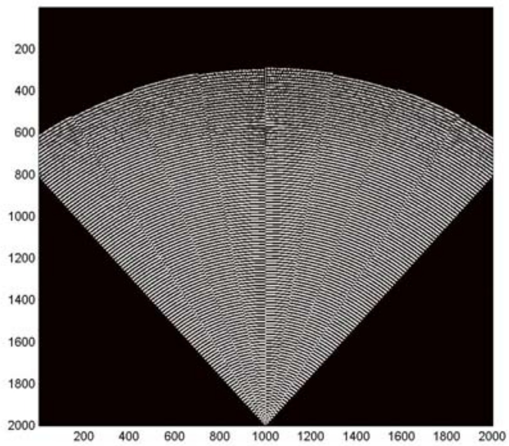
Distance Resolution = 1/2 (c/ ΔF) where ΔF is the occupied bandwidth
Thus for narrowband we have a distance resolution of 1.8m and for a UWB system, we have a potential resolution of 7.5cm

Spatial Resolution

The simulation plots below illustrate the difference in resolution between a NB and UWB radar. The scale is given in Cartesian coordinates and in cm. The radar is located at position (1000, 2000). Bore sight is along the x=1000 axis. Each checkerboard square represents a resolution cell (i.e inside this cell, the radar is unable to distinguishes two targets that have the same velocity)







ISM Band radar
Calculation parameters
Angle resolution : 10^o
Bandwidth : 80MHz
Field of view 80^o (+/-40^o from bore sight)
Simulation : 20mx20m grid, 1cm granularity, 18m depth

UWB radar
Calculation parameters
Angle resolution : 10^o
Bandwidth : 4GHz
Field of view 80^o (+/-40^o from bore sight)
Simulation : 20mx20m grid, 1cm granularity, 17m depth

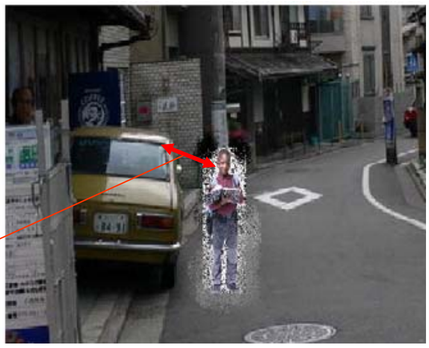
Spatial Resolution

- As can be seen, at ranges ~6-20m, the UWB achieves a very good resolution cells of the order of $0.1m^2$.
- For highly cluttered target scenarios where target discrimination by Doppler (velocity) is difficult, UWB will have a significant advantage in terms of target detection:

Real World Scenarios

- There are classes of real world scenarios related to stopped object or very low velocity object classification and also cluttered environments where differentiation via Doppler is not possible.
  - Example: a pedestrian emerging from between two parked vehicles, with a small spacing distance between the parked vehicles and the pedestrian.

The high resolution achieved by UWB radar will contribute to separate objects in these specific scenarios that would otherwise not be discriminated.



1m

10 September 2009

Update on Overview World Situation for UWB SRR frequency allocation at 24 GHz, 26 GHz and 79 GHz

1. Ultra-Wide Band Short Range Radar (SRR) supports the governmental goal of cutting traffic fatalities

- SARA is convinced that SRR is one of the most suitable technologies for safety applications because of its high availability even under bad weather conditions and at night. Customers recognize these safety benefits. The "take rate" is high at car lines where SRR is offered.

  Automotive Radar is the basic technology for automotive active and passive safety applications. Regulators in the USA and Europe have recognized that this technology offers substantial possibilities for greatly improving road safety.

  An example of active safety measure is autonomous emergency braking.

  The safety benefit of SRR has been investigated by various parties: Daimler analyzed real traffic accidents (what would have happened if the cars would have SRR on board ?) and also analyzed repair part statistics. A high percentage of accidents could be avoided and others were strongly mitigated because of the reduction of the impact speed due to SRR. The Swedish Road Administration showed that reduction of impact speed by 10% would reduce the risk of fatalities by 30%. Also the German Insurance Research came to a similar result and asked for introduction of emergency braking in the cars. These studies were published in the Enhanced Safety of Vehicle (ESV) – Conference 2009, Germany. Based on these and other inputs, insurance companies are starting to reduce insurance fees if the cars are equipped with SRR.

- Another important factor is that any automotive safety application must be affordable so that it can be introduced rapidly into the car market. For new technology such as UWB SRR it is very important to achieve economies of scale that allow the benefits of the technology to be offered as widely as possible.

- For both these factors a worldwide harmonization of the frequency allocation is of great importance.

2. Situation 24 GHz / 26 GHz band (22 – 29 GHz)

Frequency regulations have been developed in various regions. The following paragraphs give an overview of the worldwide situation:

- USA 2002: Frequency range 22 – 29 GHz. The regulation allows 24 GHz as well as 26 GHz SRR with no restrictions in time and quantity, no deactivation for Radio Astronomy.

- Europe 2005: Frequency range 21.65 – 26.65 GHz (center frequency 24.15 GHz)

- ➢ Restrictions: time limitation 2013, car fleet penetration 7%, automatic deactivation in protection ranges around Radio Astronomy sites between 1 and 35 km.
- ➢ Because of the restrictions for 24 GHz SRR a frequency regulation for the 77 – 81 GHz (center frequency 79 GHz) was created with no restrictions in time and quantity as well as no deactivation for Radio Astronomy.
- ➢ The current European 24 GHz regulation with its time limit and fleet limit fails to reflect the automotive development and production cycle. These restrictions hinder deployment of SRR and limit the number of automotive manufacturers that are able to implement the technology.

  a) Planning in automotive production cycles conflicts with the time limits placed on 24 GHz SRR[1]. Only two OEMs committed to implementing first generation SRR to various model lines, because the time frames of their product cycle fit the SRR time limits. The majority, however, cannot justify using SRR in their development and production cycles.

  b) Automotive manufacturers change model lines and introduce new models at varying times – these decisions normally are based on deployment and production cycles of seven years. Manufacturers must reliably know that new technologies are mature and available several years before the start of production of a new model line and for the entire production period, because it is not possible to make major changes during that period (due to qualification standards, product line recalibration, etc.). Business decisions in the automotive sector are extremely sensitive to the availability of components during the entire production cycle.

  With four years of experience, SARA knows now that market take-up of first generation SRR is inherently limited due to the 2013 deadline. Under current conditions, it is impossible that 24 GHz deployment in Europe will come close to extremely conservative compatibility limits or reach its potential for contributing to road safety.

  Today’s fleet penetration is far below the originally expected value. According to the annual report published at the end of June 2009 by the German road administration KBA (Kraftfahrt-Bundesamt) the fleet penetration is approximately 0,02 % of the total car fleet in Europe. This shows clearly that the current regulation with its time limit and the limit of the fleet penetration hinders the introduction of SRR.

- Europe 2009: To overcome the restrictions for 24 GHz and to avoid a gap in the availability of radar sensors because of delay in the development of 79 GHz sensors SARA asked for a **frequency evolution to the range 24 – 29 GHz** (center frequency about 26 GHz). This request was based on the fact that the 79 GHz technology is still in the research phase and will not be available to replace the 24 GHz technology in time for a seamless transition in 2013 as needed for the time limitation of the 24 GHz decision.

  - ➢ A mandate from the European Commission in November 2008 initiated this “Fundamental Review” of the frequency decision for 24 GHz, which has to be finalized in 2009. The frequency committees of CEPT started the review process in December 2008. A first report was approved by the ECC meeting in March 2009.
    In addition, the search for a new frequency allocation was started in March 2009 with compatibility studies. The process is still ongoing. In addition to compatibility studies an impact assessment is under progress which includes the benefits of SRR applications for road safety. The final review is scheduled for March 2010.

[1] This factor already has been recognized in a working document to the Radio Spectrum Committee considering future monitoring of SRR implementation (RSCom06-96, 24 November 2006).

- SARA asked also in Europe for the frequency range 24 – 29 GHz to achieve a worldwide harmonization with Japan and USA. This regulation should also avoid any restrictions in time and quantity.
- In parallel with the frequency allocation the ETSI process was started to create a new standard. In the ETSI ERM meeting of November 2008 the new work item for this process was approved.

- Other countries: Meanwhile nearly 60 countries worldwide allow the use of SRR at 24 GHz – although only Europe has applied time and penetration limits:

  - Examples are CEPT countries, including the member states of the European Union, Switzerland and Russia; South Africa; Australia; Mexico and USA. Canada has allowed the sale of cars equipped with SRR since 2006, based on a special allowance. In March 2009 Canada published its frequency regulation for UWB, which is consistent with US regulation. (Comments on the regulation were filed at end of July 2009.) Singapore also has created a regulation for 79 GHz SRR in addition to 24 GHz.
  - SARA asked in Japan for permission to use 24 GHz with a limited number of cars (cars are available with this technology since 2005) and for 26 GHz without limitations. 26 GHz regulation should avoid limitations in time and quantity. (Limits would block the wide introduction of the technology.) This approach would give a chance for a worldwide harmonization. Also an allocation for 79 GHz is proposed.

- Market situation: Cars equipped with 24 GHz have been on the road since 2005. SARA has information about car lines of Daimler, BMW, Ford, Chrysler and Mazda. Mazda uses UWB SRR in the US. Other car makers show interest in the technology and are eager to rely on a frequency regulation without restrictions in time and quantity. In the US commercial vehicles and even school buses use UWB SRR. In contrast to the deployment of SRR technology in the US the fleet introduction in Europe is extremely limited because of the European regulatory restrictions.

- Vehicle applications were introduced in high class car lines, now going also to lower classes and get more and more sophisticated.
  In 2005 SRR was introduced in the Mercedes S-class with autonomous partial braking and measures of passive safety like pre-tensioning seat-belts. In 2009 Daimler introduced SRR in the next car line, the Mercedes-Benz E-class with enhanced applications such as autonomous emergency full braking with its high safety benefit.

3. Situation 79 GHz band (77-81 GHz)

The European frequency regulation for 24 GHz currently requires a transition from 24 to 79 GHz in the year 2013. Even before this regulatory requirement was adopted, European research projects focused on 79 GHz SRR technology, and those efforts have intensified. The first research project named Kokon funded by Germany worked on semiconductor technology (2003 – 2007). A second research project started in 2008 (2008 – 2011, RoCC – Radar on Chip for Cars) to focus on sensor technology. These steps are the precondition for work on car integration, followed by extensive field tests. Both of these last steps will again take some years. It is visible today that 79 GHz technology will not be available in time for a seamless transition in 2013 as required in the European regulation for 24 GHz.

SARA member companies are working on the development of 79 GHz technology to fulfil European regulations and also because of its technical potential:

- Better Doppler (speed) information: Since Doppler shift is proportional to the frequency, a more precise speed information will be possible at 79 GHz.

- Higher angular resolution: At higher frequencies smaller antenna structures will allow a higher angular resolution. This resolution improves tracking of objects and also permits detection of an object's corners that leads to an estimation of object size and mass as a basis for adapting airbag thresholds.
- Smaller sensor size: Smaller devices could also be possible with 79 GHz technology, which simplifies the car integration, a factor that is especially important for smaller cars.
- Technology trends: There is also a technical trend to higher frequencies in general.

It is apparent that 79 GHz sensors will not meet the 2013 timeline, however, because of the long development and car integration process, which includes extensive test procedures (e.g. 1 million driven km under real road conditions for safety applications).

In preparation for when 79 GHz SRR is available, and recognizing that frequency allocation is a time consuming process, SARA already has proposed a 79 GHz frequency allocation in Japan and asks to start the allocation process in 2009.

SARA will ask for a frequency allocation also in other regions such as the USA (also in 2009) in order to achieve a second worldwide harmonized allocation for SRR.

The worldwide harmonized allocation for 79 GHz as the second frequency range for UWB SRR will make it possible to follow the technological trend to higher frequencies and also will allow further improvement of the sensor performance for applications of enhanced road safety.

It is important however to note that SRR at 24 / 26 GHz are needed to successfully prepare the market for the next generation at 79 GHz and to maintain UWB SRR in the cars..

4. Proposal for 24GHz/26GHz UWB SRR regulation in Japan

SARA wants to highlight the fact that a safety technology has to be affordable for the customer as a precondition for its contribution to road safety. Global harmonization of the frequency allocation is essential. Therefore SARA respectfully asks the Japanese government to develop a frequency regulation compatible to other regions, use an emission mask and test procedures which are consistent with European (ETSI) and US (FCC) standards.

Summary

UWB SRR is a sensor technology that permits advanced automotive safety applications. A frequency allocation in Japan consistent with the regulations in North America and Europe is an important precondition for the market introduction of that technology and its benefit for road safety.

An allocation at 24/26 GHz is essential to introduce SRR based vehicle safety technology in Japan using a technology which is available right now. This allocation at 24/26 GHz will also prepare the market for the future 79 GHz technology.

Very sincerely yours,

Dr. Gerhard Rollmann
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GR-Consulting, Ellwangerstr. 20, D 71732 Tamm, Germany
gerhard.rollmann@gr-consulting.eu

COMMISSION

COMMISSION DECISION

of 17 January 2005

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

(notified under document number C(2005) 34)

(Text with EEA relevance)

(2005/50/EC)

THE COMMISSION OF THE EUROPEAN COMMUNITIES,

Having regard to the Treaty establishing the European Community,

Having regard to Decision No 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 (Radio Spectrum Decision) [1], and in particular Article 4(3) thereof,

Whereas:

(1) The Commission communication to the Council and the European Parliament of 2 June 2003 on 'European Road Safety Action Programme — Halving the number of road accident victims in the European Union by 2010: a shared responsibility' [2] sets out a coherent approach to road safety in the European Union. Furthermore, in its communication to the Council and the European Parliament of 15 September 2003, entitled 'Information and communications technologies for safe and intelligent vehicles' [3], the Commission announced its intention to improve road safety in Europe, to be known as the *eSafety* initiative, by using new information and communications technologies and intelligent road safety systems, such as automotive short-range radar equipment. On 5 December 2003 in its conclusions on road safety [4] the Council also called for the improvement of vehicle safety by the promotion of new technologies such as electronic safety.

(2) The rapid and coordinated development and deployment of automotive short-range radar within the Community require a harmonised radio frequency band to be available for this application in the Community without delay and on a stable basis, in order to provide the necessary confidence for industry to make the necessary investments.

(3) On 5 August 2003, with a view to such harmonisation, the Commission issued a mandate, pursuant to Article 4(2) of Decision No 676/2002/EC, to the European Conference of Postal and Telecommunications Administrations (CEPT), to harmonise the radio spectrum and to facilitate a coordinated introduction of automotive short-range radar.

(4) As a result of that mandate, the 79 GHz range band has been identified by CEPT as the most suitable band for long term development and deployment of automotive short-range radar, with the introduction of this measure by January 2005 at the latest. The Commission therefore adopted Decision 2004/545/EC of 8 July 2004 on the harmonisation of the radio spectrum in the 79 GHz range for the use of automotive short-range radar equipment in the Community [5].

(5) However, automotive short-range radar technology in the 79 GHz range band is still under development and is not immediately available on a cost-effective basis, although it is understood that the industry will promote the development of such a technology in order to make it available at the earliest possible date.

(1) OJ L 108, 24.4.2002, p. 1.
(2) COM(2003) 311.
(3) COM(2003) 542.
(4) Conclusions of the Council of the European Union on road safety, 15058/03 TRANS 307.
(5) OJ L 241, 13.7.2004, p. 66.

(6) In its report of 9 July 2004 to the European Commission under the mandate of 5 August 2003, CEPT identified the 24 GHz range radio spectrum band as being a temporary solution which would enable the early introduction of automotive short-range radar in the Community to meet the objectives of the *e-Safety* initiative, since technology is considered sufficiently mature for operation in that band. Therefore, Member States should take the appropriate measures based on their particular national radio spectrum situation to make sufficient radio spectrum available on a harmonised basis in the 24 GHz range radio spectrum band (21,65 to 26,65 GHz), while protecting existing services operating in that band from harmful interference.

(7) According to footnote 5.340 of the Radio Regulations of the ITU, all emissions are prohibited in the band 23,6 to 24,0 GHz, in order to protect the use on a primary basis of this band by the radio astronomy, earth exploration satellite and space research passive services. This prohibition is justified by the fact that harmful interference to these services by emissions in the band cannot be tolerated.

(8) Footnote 5.340 is subject to national implementation and may be applied in conjunction with Article 4.4 of the Radio Regulations, pursuant to which no frequency may be assigned to a station in derogation of the Radio Regulations, except on the express condition that such a station, when using such a frequency assignment, shall not cause harmful interference to a station operating in accordance with the provision of the ITU rules. Therefore, in its report to the Commission, CEPT pointed out that footnote 5.340 does not strictly prevent administrations from using bands falling under the footnote, provided that they are neither impacting services of other administrations nor trying to have international recognition under the ITU of such use.

(9) The 23,6 to 24,0 GHz frequency band is of primary interest for the scientific and meteorological communities to measure water vapour content essential for temperature measurements for the earth exploration satellite service. In particular, this frequency plays an important role in the Global Monitoring for Environment and Security initiative (GMES) aiming at an operational European warning system. The 22,21 to 24,00 GHz frequency range is also needed to measure spectral lines of ammonia and water as well as continuum observations for the radio astronomy service.

(10) The bands 21,2 to 23,6 GHz and 24,5 to 26,5 GHz are allocated to the fixed service on a primary basis in the ITU Radio Regulations and are extensively used by fixed links to meet the infrastructure requirement for existing 2G and 3G mobile networks and to develop broadband fixed wireless networks.

(11) Based on studies of compatibility between automotive short-range radar and fixed services, earth exploration satellite services and radio astronomy services, CEPT has concluded that an unlimited deployment of automotive short-range radar systems in the 24 GHz range radio spectrum band will create unacceptable harmful interference to existing radio applications operating in this band. Considering ITU Radio Regulations and the importance of these services, any introduction of automotive short-range radar at 24 GHz could be made only on condition that these services in the band are sufficiently protected. In this respect, while the signal emanating from automotive short-range radar equipment is extremely low in most of the 24 GHz frequency range, it is important to take into account the cumulative effect of the use of many devices, which individually might not cause harmful interference.

(12) According to CEPT, existing applications operating in or around the 24 GHz band would increasingly suffer significant levels of harmful interference if a certain level of penetration of vehicles using the 24 GHz range radio spectrum band for automotive short-range radars were to be exceeded. CEPT concluded in particular that sharing between earth exploration satellite services and automotive short-range radar could only be feasible on a temporary basis if the percentage of vehicles equipped with 24 GHz automotive short-range radar was limited to 7,0 % in each national market. While this percentage has been calculated on the basis of earth exploration satellite pixels, national markets are used as the reference against which to calculate the threshold, as this represents the most effective means of carrying out this monitoring.

(13) Furthermore, the CEPT report concluded that to maintain the protection requirements of the fixed service, sharing with automotive short-range radar could only be feasible on a temporary basis if the percentage of vehicles equipped with automotive short-range radar within sight of a fixed service receiver was limited to less than 10 %.

(14) It is therefore presumed on the basis of the work carried out by CEPT that harmful interference should not be caused to other users of the band where the total number of vehicles registered, placed on the market or put into service equipped with 24 GHz automotive short-range radar does not exceed the level of 7 % of the total number of vehicles in circulation in each Member State.

(15) It is not presently anticipated that this threshold will be reached before the reference date of 30 June 2013.

(16) Several Member States also use the 24 GHz range radio spectrum band for radar speed meter control which contributes to traffic safety. Following compatibility studies with automotive short-range radar of a number of these devices operating in Europe, CEPT has concluded that compatibility is possible under certain conditions, principally by decoupling the centre frequencies of the two systems by at least 25 MHz, and that the risk of harmful interference is low and will not create false speed measurements. Manufacturers of vehicles using automotive short-range radar systems have also committed themselves to continue taking appropriate steps to ensure that the risk of interference to radar speed meters is minimal. The reliability of radar speed meter equipment will therefore not be affected by the operation of automotive short-range radar to any significant extent.

(17) Some Member States will in the future use the band 21,4 to 22,0 GHz for broadcast satellite services in the direction space-to-earth. Following compatibility studies, relevant national administrations have concluded that no compatibility problems exist if the emissions of automotive short-range radar are limited to no more than – 61,3 dBm/MHz for frequencies below 22 GHz.

(18) The above presumptions and precautions need to be kept under ongoing objective and proportionate review by the Commission assisted by the Member States, in order to assess on the basis of concrete evidence whether the threshold of 7 % will be breached in any national market before the reference date, whether harmful interference has been or is likely to be caused within a short period of time to other users of the band by the breach of the threshold of 7 % in any national market, or whether harmful interference has been caused to other users of the band even below the threshold.

(19) Therefore, as a result of information that becomes available as part of the review process, modifications to the present Decision may turn out to be necessary, in particular to ensure that there is no harmful interference caused to other users of the band.

(20) Accordingly, there can be no expectation that the band of 24 GHz will continue to be available for automotive short-range radar until the reference date, if any of the abovementioned presumptions prove not to be valid at any time.

(21) In order to facilitate and render more effective the monitoring of the use of the 24 GHz band and the review process, Member States may decide to draw more directly upon manufacturers and importers for information required in relation to the review process.

(22) As reported by CEPT, sharing between automotive short-range radar and the radio astronomy service within the 22,21 to 24,00 GHz band could lead to harmful interference for the latter if short-range radar-equipped vehicles were allowed to operate unhindered within a certain distance from each radio astronomy station. Therefore, and bearing in mind that Directive 1999/5/EC of the European Parliament and of the Council of 9 March 1999 on radio equipment and telecommunications terminal equipment and the mutual recognition of their conformity [1] requires that radio equipment must be constructed so as to avoid harmful interference, automotive short-range radar systems operating in bands used by radio astronomy in the 22,21 to 24,00 GHz range should be deactivated when moving within these areas. The relevant radio astronomy stations and their associated exclusion zones should be defined and justified by national administrations.

(23) In order to be effective and reliable, such deactivation is best done automatically. However, to allow an early implementation of automotive short-range radar in 24 GHz, a limited amount of transmitters with manual deactivation can be allowed as, with such a limited deployment, the probability of causing harmful interference to the radio astronomy service is expected to remain low.

(24) The temporary introduction of automotive short-range radar in the 24 GHz range radio spectrum band has an exceptional character and must not be considered as a precedent for the possible introduction of other applications in the bands where ITU Radio Regulations footnote 5.340 applies, be it for temporary or permanent use. Moreover, automotive short-range radar must not be considered as a safety-of-life service within the meaning of the ITU Radio Regulations and must operate on a non-interference and non-protected basis. Furthermore, automotive short-range radar should not constrain the future development in the use of the 24 GHz band of applications which are protected by footnote 5.340.

(25) The placing on the market and operation of 24 GHz automotive short-range radar equipment in a stand-alone mode or retrofitted in vehicles already on the market would not be compatible with the objective of avoiding harmful interference to existing radio applications operating in this band, since it could lead to an uncontrolled proliferation of such equipment. In contrast, it should be easier to control the use of automotive short-range radar systems in the 24 GHz band solely as part of a complex integration of the electrical harness, automotive design and software package of a vehicle and originally installed in the new vehicle, or as replacement of original vehicle-mounted automotive short-range radar equipment.

[1] OJ L 91, 7.4.1999, p. 10. Directive as last amended by Regulation (EC) No 1882/2003 (OJ L 284, 31.10.2003, p. 1).

(26) This Decision will apply taking into account and without prejudice to Council Directive 70/156/EEC of 6 February 1970 on the approximation of the laws of the Member States relating to the type-approval of motor vehicles and their trailers [1] and to Directive 1999/5/EC.

(27) The measures provided for in this Decision are in accordance with the opinion of the Radio Spectrum Committee,

HAS ADOPTED THIS DECISION:

Article 1

The purpose of this Decision is to harmonise the conditions for the availability and efficient use of the 24 GHz range radio spectrum band for automotive short-range radar equipment.

Article 2

For the purposes of this Decision, the following definitions shall apply:

1. '24 GHz range radio spectrum band' means the 24,15 +/− 2,50 GHz frequency band;
2. 'automotive short-range radar equipment' means equipment providing road vehicle-based radar functions for collision mitigation and traffic safety applications;
3. 'automotive short-range radar equipment put into service in the Community' means automotive short-range radar equipment originally installed or replacing one so installed in a vehicle which will be or which has been registered, placed on the market or put into service in the Community;
4. 'on non-interference and non-protected basis' means that no harmful interference may be caused to other users of the band and that no claim may be made for protection from harmful interference received from other systems or services operating in that band;
5. 'reference date' means 30 June 2013;
6. 'transition date' means 30 June 2007;
7. 'vehicle' means any vehicle as defined by Article 2 of Directive 70/156/EEC;
8. 'deactivation' means the termination of emissions by automotive short-range radar equipment;
9. 'exclusion zone' means the area around a radio astronomy station defined by a radius equivalent to a specific distance from the station;
10. 'duty cycle' means the ratio of time during any one-hour period when equipment is actively transmitting.

Article 3

The 24 GHz range radio spectrum band shall be designated and made available as soon as possible and no later than 1 July 2005, on a non-interference and non-protected basis, for automotive short-range radar equipment put into service in the Community which complies with the conditions laid down in Articles 4 and 6.

The 24 GHz range radio spectrum band shall remain so available until the reference date, subject to the provisions of Article 5.

After that date, the 24 GHz range radio spectrum band shall cease to be available for automotive short-range radar equipment mounted on any vehicle except where that equipment was originally installed, or is replacing equipment so installed, in a vehicle registered, placed on the market or put into service before that date in the Community.

Article 4

The 24 GHz range radio spectrum band shall be available for the ultra-wide band part of automotive short-range radar equipment with a maximum mean power density of −41,3 dBm/MHz effective isotropic radiated power (e.i.r.p.) and peak power density of 0 dBm/50MHz e.i.r.p., except for frequencies below 22 GHz, where the maximum mean power density shall be limited to -61,3 dBm/MHz e.i.r.p.

The 24,05 to 24,25 GHz radio spectrum band is designated for the narrow-band emission mode/component, which may consist of an unmodulated carrier, with a maximum peak power of 20 dBm e.i.r.p. and a duty cycle limited to 10 % for peak emissions higher than −10 dBm e.i.r.p.

Emissions within the 23,6-24,0 GHz band that appear 30° or greater above the horizontal plane shall be attenuated by at least 25 dB for automotive short-range radar equipment placed on the market before 2010 and thereafter by at least 30 dB.

Article 5

1. The continued availability of the 24 GHz range radio spectrum band for automotive short-range radar applications shall be kept under active scrutiny to ensure that the main premise of opening this band to such systems remains valid, which is that no harmful interference is caused to other users of the band, in particular through the timely verification of:

[1] OJ L 42, 23.2.1970, p. 1. Directive as last amended by Commission Directive 2004/104/EC (OJ L 337, 13.11.2004, p. 13).

(a) the total number of vehicles registered, placed on the market or put into service equipped with 24 GHz automotive short-range radar in each Member State, to verify that this number does not exceed the level of 7 % of the total number of vehicles in circulation in each Member State;

(b) whether adequate information has been made available by Member States or by manufacturers and importers regarding the number of 24 GHz short-range radar-equipped vehicles for the purpose of monitoring effectively the use of the 24 GHz band by automotive short-range radar equipment;

(c) whether the individual or cumulative use of 24 GHz automotive short-range radar is causing or is likely to cause within a short period of time harmful interference to other users in the 24 GHz band or in adjacent bands in at least one Member State, whether or not the threshold referred to in (a) has been reached;

(d) the continuing appropriateness of the reference date.

2. In addition to the review process in paragraph 1, 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.

3. The fundamental review may be triggered by a reasoned request by a member of the Radio Spectrum Committee, or at the Commission's own initiative.

4. The Member States shall assist the Commission to carry out the reviews referred to in paragraphs 1 and 2 by ensuring that the necessary information is collected and provided to the Commission in a timely manner, in particular the information set out in the Annex.

Article 6

1. Automotive short-range radar equipment mounted on vehicles shall only operate when the vehicle is active.

2. Automotive short-range radar equipment put into service in the Community shall ensure protection of the radio astronomy stations operating in the radio spectrum band 22,21 to 24,00 GHz defined in Article 7 through automatic deactivation in a defined exclusion zone or via another method providing equivalent protection for these stations without driver intervention.

3. By way of derogation to paragraph 2, manual deactivation will be accepted for automotive short-range radar equipment put into service in the Community operating in the 24 GHz range radio spectrum band before the transition date.

Article 7

Each Member State shall determine the relevant national radio astronomy stations to be protected pursuant to Article 6(2) in its territory and the characteristics of the exclusion zones pertaining to each station. This information, supported by appropriate justification, shall be notified to the Commission within six months of adoption of this Decision, and published in the *Official Journal of the European Union*.

Article 8

This Decision is addressed to the Member States.

Done at Brussels, 17 January 2005.

For the Commission

Viviane REDING

Member of the Commission

ANNEX

Information required for monitoring the use of the 24 GHz range radio spectrum band by automotive short-range radar

This Annex establishes the data required to verify the penetration rate of automotive vehicles equipped with short-range radar in each Member State of the European Union in accordance with Article 5. This data shall be used to calculate the proportion of vehicles equipped with short-range radar using the 24 GHz range radio spectrum compared to the total number of vehicles in circulation in each Member State.

The following data shall be collected on a yearly basis:

(1) the number of vehicles equipped with short-range radar using the 24 GHz range radio spectrum band produced and/or placed on the market and/or registered for the first time during the reference year in the Community;

(2) the number of vehicles equipped with short-range radar using the 24 GHz range radio spectrum band imported from outside the Community during the reference year;

(3) the total number of vehicles in circulation during the reference year.

All data shall be accompanied by an evaluation of the uncertainty related to the information.

In addition to the above data, any other relevant information which would assist the Commission in maintaining an adequate overview on the continued use of the 24 GHz range radio spectrum band by automotive short-range radar devices shall be made available in a timely fashion, including information on:

— current and future market trends, both within and outside the Community,

— after-market sales and retrofitting of equipment,

— the state of progress of alternative technologies and applications, notably automotive short-range radar operating in the 79 GHz range radio spectrum band according to Decision 2004/545/EC.

EUROPEAN COMMISSION
Information Society and Media Directorate-General

Electronic Communications Policy
Radio Spectrum Policy

Brussels, 1 July 2008
DG INFSO/B4

RSCOM08-51

PUBLIC DOCUMENT

RADIO SPECTRUM COMMITTEE

Working Document

Subject: **Automotive short-range radars: third annual SRR report and request by SARA to review the EC Decision on the use of the 24 GHz band by 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.

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1. INTRODUCTION

This document addresses the third annual report provided by SARA on the monitoring of the use of the 24 GHz band by automotive short-range radars under Commission Decision 2005/50/EC over the period from June 2007 to May 2008.

It also introduces the information document prepared by SARA (see RSCOM#24 item 12), which requests a fundamental review as provided in the text of the Decision to be initiated.

2. THIRD ANNUAL REVIEW OF THE USE OF THE 24 GHZ BAND BY AUTOMOTIVE SRR

Article 5 of the 24 GHz SRR Decision establishes the need to monitor the use of 24 GHz automotive short-range radars, while the Annex describes the data necessary to perform the review of the Decision. The commitment of automotive companies using SRR to provide monitoring information is described in the Explanatory Memorandum to the Decision (RSCOM04-80Rev2) and in the Memorandum of Understanding relating to the implementation of active safety automotive short-range radars (RSCOM04-81Rev2).

Upon presentation of the first draft annual report by SARA in June 2006, the specific modalities on monitoring the 24 GHz band were agreed by RSC and the first annual report accepted. The second annual report prepared by SARA following the agreed guidelines was accepted by the RSC in its October 2007 meeting (RSC#21, see document RSCOM07-61).

The third annual SRR report is in **annex 1** to this document. The key figure in the report is that SRR-equipped cars represent as of mid-2008 approximately 0.01% of the total number of cars operating the EU[1].

This number, formally computed by KBA, the Federal German Motor Transport Authority, is well below the 7% threshold identified as potentially harmful to radio services operating in the 24 GHz range.

In the Commission services' view, the penetration trend in the last three years does not give rise to any concern that the 7% threshold could be reached before the 2013 expiry date of the EC Decision. There is therefore no need to consider remedial action in this respect.

Administrations are invited to give their views on whether the third SARA industry monitoring report pursuant to Art. 5 of EC Decision 2005/EC/50 is acceptable to the RSC.

3. REVIEW OF THE 24 GHZ DECISION

Document RSCOM#24 item 12 is a submission by SARA requesting the Commission and the Radio Spectrum Committee to initiate the fundamental review of the automotive short-range radar equipment operating in the 24 GHz radio spectrum band.

Article 5.2 of the Decision states:

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[1] To recall, the RSC agreed that a national breakdown of SRR penetration was not required in the first three years of SRR operation in the 24 GHz range.

"... 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.

...The fundamental review may be triggered by a reasoned request by a member of the Radio Spectrum Committee, or at the Commission's own initiative."

It is clear that while the review was intended to address any harmful interference issues emerging from the operation of SRR (for instance in case the 7% upper limit of SRR penetration was under threat), its scope was not meant to be limited exclusively to such issues. The effectiveness of the current spectrum regulatory framework for enabling active safety SRR applications in the automotive sector should also be subject to consideration after the first few years of operation.

In its document, SARA advocates that neither the 24 GHz band nor the 79 GHz band, as regulated by their respective EC Decisions, are currently able to allow a full take-up of short-range radar safety applications in Europe in the short- to medium-term. It therefore proposes a possible option of "calibrating" the operation of SRR by shifting the operating range to around 26 GHz (between 24.25 and 29 GHz).

The main benefit of this approach is argued by SARA to lie in the removal of the need to limit SRR penetration and therefore its monitoring, as well as the consequent time limit on use of the spectrum. An additional advantage would be that SRR systems would not require automatic switch-off around radio astronomy sites. A shift to the upper frequency has been agreed in the US and is under consideration in other regions.

Before a decision is taken on whether this approach should be pursued in the EU, the technical feasibility of operating SRR applications without harmful interference to other users in the amended frequency range should be explored. A number of applications already operate in the frequencies above 24 GHz in Europe, notably fixed links, fixed satellite services and some military communication systems.

In order to characterise the potential interference environment of a possible operation of SRR above 24 GHz, it is expected that both CEPT and ETSI would need to undertake some dedicated work, possibly framed by Commission mandates. These exploratory activities may require some considerable time to be finalised.

The Commission services will consider carefully the proposal by SARA and the reactions of the members of the RSC. Without prejudice to the discussions in the RSC, the Commission is minded to agree to begin the formal process of fundamental review of Decision 2005/50/EC at the October 2008 meeting of RSC.

The review is the appropriate mechanism to allow the merits of the SARA proposal to be evaluated, as well as give an indication of the cost-benefits of undertaking this approach. Te views of affected parties as well as alternative scenarios, such as the state of progress of SRR technology in the 79 GHz range could also be explored in more detail.

Administrations are invited to give their views on the proposal to initiate the fundamental review of EC Decision 2005/EC/50 at RSC#25 (October 2008).

Attached: SARA third annual report on 24 GHz SRR

20 June 2008

To: European Commission

From: **S**trategic **A**utomotive **R**adar frequency **A**llocation group

Subject: Report on the use of the 24 GHz frequency range by automotive short-range radars as of June 2008

The **S**trategic **A**utomotive **R**adar frequency **A**llocation group (SARA)[2] pledged in a Memorandum of Understanding (MoU) to provide information on 24 GHz ultra-wideband short range radar (SRR) to assist the monitoring required in Commission Decision 2005/50/EC (the Decision).[3] This third report is submitted for the period June 2007 to end of May 2008, and has been complied in accordance with agreed procedures stated in Doc. RSCOM06-54, dated 16 June 2006, from SARA. As detailed below, SARA reports that penetration of SRR-equipped vehicles is about 0.01% of the total number of vehicles in the European Union as of the end of May 2008.[4]

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2 SARA was formed in 2001 as the **S**hort Range **A**utomotive **R**adar Frequency **A**llocation group; its mission to seek global harmonization 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.

3 Commission Decision of 17 January 2005 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, O.J. L 21, 25 January 2005, page 15.

4 This report contains no business-confidential information and can be made publicly available.